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Capturing Wear in Wear and Tear: The Negative-Affect Reactivity Linked to Discrimination Is Associated With Biological Age Across Two National Samples of Adults in the United States

Juan Del Toro[1], Connor Martz[2], Sauro Civitillo[3], and Katerina M. Marcoulides[1]

[1] Department of Psychology, University of Minnesota–Twin Cities

[2] Department of Population Health Sciences, University of Central Florida

[3] European Research Centre on Migration and Ethnic Relations, Utrecht University

Objective: Chronic psychological stress responses to discrimination may be associated with more accelerated paces of biological aging at a particular window of time through epigenetic changes in DNA methylation, including in third-generation epigenetic clocks (i.e., the DunedinPACE and GrimAge2). Although discrimination is often measured by frequency, fewer studies examine how its cumulative psychological toll is associated with biological age acceleration, which is a theoretical proposition aligned with the weathering hypothesis. ***Methods:*** The present study analyzed data from two national longitudinal studies: 397 adults completing eight daily diaries in the Midlife in the United States study and 2,059 adults completing five biennial surveys in the Health and Retirement Study. We modeled the within-person associations (i.e., slopes) between discrimination and negative affect as correlates of biological aging captured by the DunedinPACE and GrimAge2 clocks. ***Results:*** Across both studies, adults who experienced more discrimination, on average, reported more negative affect. Stronger positive slopes between discrimination and negative affect were associated with faster paces of biological aging at the time of assessment in only the DunedinPACE clock in the Midlife in the United States study and in the DunedinPACE and GrimAge2 clocks in the Health and Retirement Study. These associations persisted after adjusting for the frequency of discrimination, highlighting the importance of modeling stress reactivity rather than exposure alone. ***Conclusions:*** Findings support the weathering hypothesis, suggesting cumulative negative emotions linked to discrimination relate to accelerated biological aging. Future research could leverage longitudinal approaches to identify vulnerable populations and inform interventions to reduce the biological embedding of discrimination.

Public Significance Statement

The emotional toll of discrimination may predict how fast adults age at a cellular level. According to two national studies of adults, adults who reacted with stronger negative emotions to discrimination showed signs of more rapid biological aging, which can increase the risk of developing chronic diseases over time. These findings highlight that it is not just the frequency of unfair treatment that matters for long-term health but the cumulative "wear and tear" it places on the body.

Keywords: biological age, weathering, discrimination, negative affect

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Juan Del Toro https://orcid.org/0000-0001-8625-026X

Connor Martz https://orcid.org/0000-0003-3155-0729

Sauro Civitillo https://orcid.org/0000-0001-7607-0935

Katerina M. Marcoulides https://orcid.org/0000-0001-8829-870X

Connor Martz and Sauro Civitillo contributed equally as second authors.

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continued

Biological age can shift under persistent exposures to adversity, including discrimination (Shonkoff et al., 2009). Discrimination, or the unjust or prejudicial treatment of individuals based on their actual or perceived membership in social groups (American Psychological Association, 2019), reflects the interpersonal manifestation of structural inequalities, including but not limited to racism, sexism, heterosexism, and classism. These systems create stressful environments that disproportionately burden marginalized social groups (e.g., race/ethnicity, gender, sexual orientation, socioeconomic status, age, disability status) and can accelerate biological aging at a particular window of time. Faster paces of aging have been documented among adults of color, women, and sexual minorities compared with White (Crimmins et al., 2021), male (Bourassa et al., 2024), and heterosexual adults (Rivera et al., 2024). Yet, studies linking discrimination to biological age often report such associations are statistically not significant (Cuevas et al., 2024; Dhingra et al., 2025; Markon et al., 2024), calling the need for more theory-driven methods.

Epigenetic changes via DNA methylation can provide novel insights about the biological underpinnings of aging (Ferrucci et al., 2020; Schumacher et al., 2021). DNA methylation is one theorized molecular mechanism that regulates gene expression, potentially causing lasting changes in physiological functioning that contribute to the pathogenesis of chronic disease (Gensous et al., 2017). Advances in quantifying DNA methylation have led to the development of epigenetic clocks as cellular proxies of biological age (Binder & Horvath, 2022; Ryan, 2021). Epigenetic clocks are derived from machine learning approaches and are based on DNA methylation patterns that are linked to various aging-related phenotypes and health outcomes. The development of epigenetic clocks has progressed over the years, with recent clocks representing better indicators of biological age than early clocks. First-generation clocks were trained to predict chronological age, and second-generation clocks were developed from DNA methylation correlates of health-risk scores (Binder & Horvath, 2022). Third-generation epigenetic clocks of the many include the DunedinPACE and GrimAge2 clocks, which capture distinct dimensions of biological aging (Belsky et al., 2022; Lu et al., 2022). The DunedinPACE clock captures the dynamic pace of biological aging at a given moment in time and the current functional status of multiple organ systems (Belsky et al., 2022), and the GrimAge2 clock is an epigenetic clock for mortality risk that approximates biological age in units of years (Lu et al., 2022).

The current study advances research on the biological risks of discrimination by applying an analytic approach that captures how the psychological tolls of discrimination accumulate over time and how these tolls are associated with biological aging. We used two national longitudinal data sets: An 8-day daily diary from the Midlife in the United States (MIDUS) study and five biennial waves from the Health and Retirement Study (HRS). Daily diaries minimize recall bias and capture fine-grained intraindividual changes, whereas biennial studies reveal longer term trends. Combining complementary studies offers richer insight than a single study into how discrimination shapes aging over time.

Biological Age Acceleration and Discrimination

According to the weathering hypothesis, chronic activation of psychological stress responses due to repeated exposure to discrimination is a significant source of biological age acceleration (Geronimus et al., 2006; Ghanooni et al., 2022; Martin et al., 2022). The theory captures a multistage and multilevel process, as the discomfort linked to discrimination may lead individuals to feel sad (Clark et al., 1999; Del Toro & Wang, 2023), ruminate and anticipate more discrimination (Bernard et al., 2022; Himmelstein et al., 2015), and internalize negative world views (Clark et al., 1999; Goosby et al., 2018). The chronicity of discrimination activating these psychological stress responses can alter primary biological stress systems and downstream biological systems (e.g., inflammation), resulting in a multisystem biological dysregulation (i.e., allostatic load; Adam et al., 2015; Dickerson & Kemeny, 2004).

Weathering is an adaptive process that responds to context. Daily discrimination includes encounters that are covert (e.g., "People act as if they think you are not smart."), making it difficult for victims of discrimination to understand whether a perpetrator's actions were attributable to prejudice (i.e., attributional ambiguity; Major & Dover, 2016). This ambiguity can lead individuals to ruminate and question the perpetrator's motives following some situations of discrimination but not for other situations. Even overt discrimination (e.g., "You are called names or insulted.") may vary in impact based on individuals' appraisal of the situation (Benner et al., 2024; Folkman, 2013). When discrimination is appraised as threatening, stress management systems involve secretion of stress hormones, increases in heart rate and blood pressure, protective mobilization of nutrients, redirection of blood perfusion to the brain, and induction of vigilance and fear (Adam et al., 2023; McEwen, 2000; Shonkoff et al., 2009). These responses are essentially protective but are pathogenic when such stress management systems are persistently activated (Boyce & Ellis, 2005; Shonkoff et al., 2009).

This situation-level variability is not reflected in the literature, as most studies focus on how the frequency of discrimination is associated with accelerated biological aging. Studies found that the frequency of discrimination was not significantly associated with accelerated biological aging in the Dunedin clocks among adults of color in the HRS (Beydoun et al., 2022) and Black adults in the MIDUS study (Cuevas et al., 2024). A recent meta-analysis

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Correspondence concerning this article should be addressed to Juan Del Toro, Department of Psychology, University of Minnesota–Twin Cities, Elliott Hall, 75 East River Parkway, Office S351, Minneapolis, MN 55455, United States. Email: jdeltoro@umn.edu

also found that the frequency of discrimination was not significantly related to telomere length across six empirical studies (Lawrence et al., 2022). These findings may suggest variability in responses to discrimination, highlighting that the frequency alone may not adequately represent how often discrimination primes individuals' sense of threat. We adapt an analytic framework to capture how the chronic psychological toll of discrimination may relate to accelerated biological aging.

A Slope as a Predictor

In line with the weathering hypothesis, cumulative effects of discrimination on stress responses contribute to more rapid biological aging (Geronimus, 2023). This multilevel process involves intraindividual psychological stress responses accumulating over time, leading to between-person differences in biological aging (Geronimus, 2023). Interindividual differences can be influenced by the strength of the association between discrimination and a psychological outcome modeled at the intraindividual level (Yip et al., 2020). This association can be statistically modeled as a random slope (Yip et al., 2020), quantifying the change in a psychological outcome in relation to a unit change in discrimination, contrasting with prior studies' focus on mean frequencies of discrimination.

Although not directly related to discrimination, prior studies have applied a slope-as-a-predictor framework in stress reactivity. In a 10-year longitudinal study among 711 adults, adults who reported more negative affect following stressful events (e.g., an argument) during an 8-day daily diary reported greater psychological distress and affective disorders 10 years later (Charles et al., 2013). In another study of 150 adults, those who reported stronger within-person associations between negative affect and stressful event appraisals during a 14-day daily diary reported general distress and depressive symptoms 1 year later (Mandel et al., 2015). These studies suggest that daily experiences can shape downstream health conditions months and years later. We apply this slope-as-a-predictor model to capture how chronic reactivity following discrimination may relate to accelerated biological aging.

The Present Study

The current study advances research on the biological risks of discrimination by applying an analytic approach that captures how psychological tolls of chronic discrimination accumulate over time and associate with accelerated biological aging throughout adulthood. We posed two research questions: (a) Was discrimination associated with more negative affect at the intraindividual level? and (b) Was this within-person association between discrimination and negative affect associated with more between-person differences in accelerated biological aging in the DunedinPACE and GrimAge2 clocks? In line with the weathering hypothesis (Geronimus, 2023), we predicted that adults who reported more discrimination would, on average, report more negative affect. We also predicted that adults who reported stronger within-person associations between discrimination and negative affect would, on average, show more accelerated biological aging.

To test our hypotheses, we leveraged longitudinal data from two national samples of adults. Study 1 used data from the 8-day daily diary component of the MIDUS study, and Study 2 used data from five biennial waves as part of the HRS. The high frequency of assessments and the immediate intervals between each assessment in a daily diary helps adjust for time-varying confounds, improving the present study's internal validity. The large sample size of the HRS augmented the present study's external validity. Altogether, both studies offer methodological strengths among samples representing a significant portion of the population in the United States.

Study 1

Study 1 served as an initial assessment of associations among discrimination, negative affect, and biological age acceleration, using 8 days of daily diary data among midlife adults.

Methods

Participants and Procedure

Table 1 presents demographic information for our analytic sample of 397 adults from the MIDUS study. Of the 397 adults, 257 (65% of the sample) self-identified as a social minority, including as an adult of color, female adult, or sexual minoritized adult. The MIDUS study began in 1995–1996 as an ongoing national longitudinal survey of adults' psychosocial and health outcomes. After their baseline assessment in 1995–1996, the MIDUS followed up on baseline assessments of psychological, sociodemographic, and health variables in 2004–2005. During this follow-up, the MIDUS study was known as MIDUS-II, which included two substudies: the National Study of Daily Experiences (NSDE)-II and the MIDUS-II Biomarker Project. Both the NSDE-II and the MIDUS-II Biomarker Project collected data from 2004 to 2009. Drawing from the MIDUS-II pool of participants, the NSDE-II recruited a subsample for a daily diary study, and the MIDUS-II Biomarker Project recruited an overlapping subsample to examine behavioral, psychological, and social factors in aging health, with blood draws to procure DNA methylation data. To assess whether daily experiences preceded accelerated biological aging, we focused on adults who completed the NSDE-II before the MIDUS-II Biomarker Project. Of the 1,310 adults with epigenetic data, 672 adults also had daily diary data. Among them, 397 adults completed daily diaries 0.25–4.67 years before blood draws, whereas 275 adults provided blood samples before completing diaries. Our analyses included 397 adults whose daily diaries temporally preceded biological data, yet we included the remaining 275 adults in our sensitivity analyses. The supplemental materials report differences in key constructs between included and excluded samples. The University of Minnesota's Institutional Review Board deemed the present study not to be human subjects research, given our use of de-identified, publicly available data.

Measures

Biological Age Acceleration. Whole blood samples were collected using a BD Vacutainer Tube with EDTA anticoagulant, frozen for storage, and subjected to DNA extraction. After MIDUS tested for suitable yield and integrity, DNA underwent genome-wide methylation profiling using the Illumina Methylation EPIC microarray. After standard quality control protocols, $n = 1{,}310$ methylation profiles were scored using previously published algorithms to compute the DunedinPACE (Belsky et al., 2022) and

Table 1
Descriptive Statistics of Key Study Constructs Among Adults in the Midlife in the United States (MIDUS) Study and Adults in the Health and Retirement Study (HRS)

Demographic variable	Statistic	MIDUS adults (N = 397)	HRS adults (N = 2,059)
Race/ethnicity			
Non-Latinx White adults	% (*n*)	83.60 (332)	69.50 (1,431)
Non-Latinx Black adults	% (*n*)	5.30 (21)	15.80 (326)
Latinx adults	% (*n*)	4.00 (16)	12.00 (248)
Non-Latinx Other adults of color	% (*n*)	7.10 (28)	2.60 (53)
Sex			
Female adults	% (*n*)	56.20 (223)	51.90 (1,068)
Male adults	% (*n*)	43.80 (174)	48.10 (991)
Sexual orientation			
Heterosexual adults	% (*n*)	93.50 (371)	61.20 (1,261)
Sexual minority adults	% (*n*)	5.80 (23)	4.10 (85)
Missing data	% (*n*)	0.80 (3)	34.60 (713)
Chronological age	*M* (*SD*)	50.44 (12.10)	61.66 (9.45)
Highest education attained			
12 years or less in school	% (*n*)	2.00 (8)	18.70 (386)
High-school or equivalent degree	% (*n*)	14.10 (56)	33.70 (694)
Some years in college	% (*n*)	29.20 (116)	25.00 (515)
College or more advanced degree	% (*n*)	54.70 (217)	22.00 (454)
Ever smoked	% (*n*)	35.80 (142)	30.00 (618)
DunedinPACE	*M* (*SD*)	−0.12 (0.93)	0.13 (0.99)
GrimAge2	*M* (*SD*)	−0.11 (0.88)	0.31 (1.05)
Negative affect	*M* (*SD*)	1.59 (1.97)	1.78 (0.59)
Daily discrimination	*M* (*SD*)	0.20 (0.40)	1.60 (0.66)

GrimAge2 clocks (Lu et al., 2022). More information on data collection and the derivation of biological age is available on the MIDUS study's Colectica Portal (https://midus.colectica.org/). After we regressed the GrimAge2 clock on chronological age to obtain a residual score for biological age acceleration, both the DunedinPACE and GrimAge2 clocks were standardized among the initial sample of 1,310 adults. After we documented evidence of construct validity in the supplemental materials, we restricted our analysis to the analytic sample of 397 adults. High DunedinPACE and GrimAge2 values indicated more accelerated biological aging.

Daily Negative Affect. Each day, adults completed the negative affect subscale of the Positive and Negative Affect Scale (Watson et al., 1988). Using 5-point Likert scales (0 = *none of the time*, 4 = *all of the time*), adults reported their negative affect each day (14-item; e.g., *How much of the time today did you feel so sad nothing cheered you up?* $\alpha = .86$). As is common with intensive longitudinal data, we tested whether we could reliably detect change over time in daily negative affect, using variance decomposition methods to estimate R_{Change} indices (Bolger & Laurenceau, 2013). These R_{Change} indices are based on generalizability theory and partition the variance within a set of scores into conceptually meaningful parts (e.g., variance due to items, persons, and waves) and their interactions along with an error component. These estimates from variance decomposition methods can be used to estimate the reliability of a measure to detect systematic change over time (i.e., R_{Change}), which was the case for daily negative affect ($R_{Change} = .79$). Thus, the 14 items on each day were-mean scored so that high values reflected more negative emotions.

Daily Discrimination. Each day, adults completed the Daily Discrimination Scale (Williams et al., 1997; i.e., nine-item; e.g., *You were treated with less respect than others?*; 0 = *no*, 1 = *yes*; $\alpha = .74$, $R_{Change} = .85$). A count score summing adults' responses was skewed (skewness = 10.66); to address this nonnormal distribution, the measure resulted in a categorical score of whether discrimination occurred (0 = no discrimination experiences occurred, 1 = at least one discrimination instance occurred). Evidence of construct validity emerged for this categorical measure of daily discrimination in the supplemental materials. Thus, discrimination reflected whether discrimination occurred each day.

Covariates. Time-varying covariates included time (range = 0–7), weekend (0 = weekday, 1 = weekend), and prior-day negative affect. Time-invariant covariates included adults' race/ethnicity (i.e., non-Latinx Black: 0 = non-Latinx White, 1 = non-Latinx Black; Latinx: 0 = non-Latinx White, 1 = Latinx, multiracial: 0 = non-Latinx White, 1 = non-Latinx multiracial), sex (0 = *female*, 1 = *male*), sexual orientation (0 = *heterosexual*, 1 = *sexual minority*) chronological age (range = 25–82), smoking (one-item; i.e., *Ever smoked cigarettes regularly?* 0 = *no*, 1 = *yes*), educational attainment (i.e., three categorical variables referencing adults with less than a high-school equivalent degree), and the time lag in years between participants' participation in the NSDE-II and the MIDUS-II Biomarker projects (range = 0.25–4.67). Measures of blood cell type composition were not publicly available in the MIDUS study, but we used the available data that included eight gene transcript variables that mark major leukocyte subsets, which are often used as covariates to control for variation in blood cell pool composition (MIDUS, 2023). Including these eight variables as time-invariant covariates did not change our results (see Table S2 in the supplemental materials).

Missing Data

Among the 397 adults, 81% of them completed all eight diaries; 15% of them completed six to seven diaries; 3% of them completed four to five diaries; and the remaining 1% completed at least two diaries. According to zero-order bivariate correlations, adults' count of missing diaries was not significantly related to their

race/ethnicity, $F(3, 393) = 0.79$, $p = .50$; sex, $t(391) = 1.53$, $p = .13$; sexual orientation, $t(24) = 1.37$, $p = .18$; chronological age ($r = .04$, $p = .38$); education attained, $F(3, 393) = 0.31$, $p = .82$; and smoking behavior, $t(254) = 1.84$, $p = .07$. After adjusting for these demographic differences, rates of missing diaries completed were not significantly related to adults' negative affect ($r_{sp} = -.05$, $p = .57$), but adults who completed more diaries were, on average, less likely to experience discrimination, $t(395) = 5.54$, $p < .001$, and experience decelerated aging in the DunedinPACE ($r_{sp} = -.10$, $p < .05$) and GrimAge2 clocks ($r_{sp} = -.12$, $p < .05$). Because discrimination and the clocks are our key variables, their inclusion in the Bayesian full-information Markov chain Monte Carlo estimation (Asparouhov & Muthén, 2021) helps account for this systematic missingness. Consistent with recommendations for handling missing at random (MAR) data (Enders, 2025), incorporating predictors of missingness into the model reduces the likelihood of biased parameter estimates and allows retention of all variable observations. However, as MAR cannot be directly tested, results should be interpreted with this assumption in mind.

Analytic Plan

In Mplus Version 9 (Muthén & Muthén, 1998), we estimated two multilevel structural equation models with Bayesian estimation, which offers the most optimal performance with both fixed and random effects, as the Bayes estimator leverages posterior distributions to provide a more accurate representation of estimation uncertainty (Muthén, 2010; Peralta et al., 2022). With Bayesian estimation, significance of each coefficient estimate (B) is determined by whether the 95% confidence interval (CI) includes zero, and each estimate's posterior standard deviation is reported and reflects uncertainty in estimated parameters similar to standard errors in frequentist statistics. The intraclass correlation coefficients (ICCs) in Table S1 in the supplemental materials justified our multilevel framework, assigning time to Level 1 and person to Level 2. Notably, the ICC for daily discrimination was .16, indicating strong situational variability in discrimination experiences across days. Level 1 continuous measures were person-mean centered, and Level 2 continuous variables were sample-mean centered (Hamaker & Muthén, 2020). In Model 1 with fixed effects and a random intercept, we regressed time-varying negative affect on time-varying discrimination at Level 1 to examine whether adults, on average, reported more negative affect on days when they experienced discrimination relative to days when they did not experience discrimination. In Model 2 with fixed effects, a random intercept, and a random slope, the time-varying relation between negative affect and discrimination was modeled as a random slope at Level 2. We then regressed the DunedinPACE and GrimAge2 clocks on this slope to test whether intraindividual relations between discrimination and negative affect were associated with greater interindividual differences in accelerated biological aging. The supplemental materials present an example of the within- and between-person equations for Study 1's Model 2.

Results

Tables 1 and 2 present descriptive statistics of key constructs and zero-order bivariate correlations among them, respectively. Across 8 days, 80 adults (20% of the sample) reported discrimination at least once, with a total of 247 discrimination instances. Discrimination was significantly associated with greater negative affect at the within-person level ($r = .24$, $p < .01$) but was not significantly associated with either the DunedinPACE ($r = -.02$, $p = .69$) or the GrimAge2 clocks ($r = .02$, $p = .74$) at the between-person level.

Table 2

Zero-Order Bivariate Correlations Between Constructs in the Midlife in the United States (MIDUS) Study and in the Health and Retirement Study (HRS)

Within-person measures	1	2	3	4
1. Time (wave/day)	—		.00	.00
2. Weekend	.11**	—		
3. Negative affect	−.12**	−.07**	—	.42**
4. Daily discrimination	−.09**	−.04**	.24**	—

Between-person measures	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Black adults	—	−.16**	−.07**	−.08**	−.04	−.13**	.14**	.02	−.02	−.06*	.07**	.01	.20**	.16**
2. Latinx adults	−.05	—	−.06**	.05*	.27**	−.13**	.01	−.08**	−.04*	−.11**	−.02	.01	.06**	−.01
3. Other adults of color	−.06	−.06	—	−.02	.02	−.09**	.03	.02	−.02	−.01	.09**	.08**	−.04	−.01
4. Male adults	−.11*	−.08	.07	—	.04	.06**	−.07**	.00	−.06*	.04	.08**	−.11**	.06**	.18**
5. Sexual minority adults	−.01	−.05	.01	.04	—	.02	.00	−.05	−.05	−.07**	−.03	.01	.07*	.05
6. Chronological age	−.08	.04	−.02	.04	.08	—	−.30**	.05*	−.10**	−.01	−.22**	−.21**	.08**	−.02
7. Ever smoked	−.01	−.04	.02	−.03	.08	.13**	—	.03	.04	−.15**	.08**	.15**	.23**	.46**
8. High school or equivalent	.03	−.01	.00	−.17**	−.04	.06	.17**	—	−.41**	−.38**	−.02	−.01	.04	.04*
9. Some college years	.10	−.05	.06	−.02	.08	−.03	.02	−.26**	—	−.31**	.04	.01	−.05*	−.01
10. College or advanced degree	−.10*	.06	−.05	.13**	−.03	−.04	−.16**	−.45**	−.70**	—	−.04*	−.04	−.17**	−.19**
11. Daily discrimination	.11*	−.01	.03	.02	.01	−.08	.00	−.09	−.01	.09	—	.47**	.02	.04
12. Negative affect	.01	.02	−.03	−.08	.07	−.11**	.04	−.05	.15**	−.09	.25**	—	.02	.03
13. DunedinPACE	.13**	.05	.10	−.02	.08	.29**	.32**	.13**	.12*	−.22**	−.02	.05	—	.66**
14. GrimAge2	.11*	.02	.06	.08	.13*	.01	.45**	.15**	.03	−.15**	.02	.08	.68**	—

Note. Values below the diagonal reflect estimates from the MIDUS study; values above the diagonal reflect estimates from the HRS.
* $p < .05$. ** $p < .01$.

The Main Effect of Daily Discrimination on Daily Negative Affect

The left portion of Table 3 presents a model examining the daily relations between discrimination and negative affect, accounting for time-variant and -invariant covariates. On average, adults reported more negative affect on days when they experienced discrimination compared with days when they did not ($B = 0.16$, 95% CI [0.12, 0.21]).

The Slope for Discrimination and Negative Affect Is Associated With Accelerated Biological Aging

The right half of Table 3 presents a model regressing the DunedinPACE and GrimAge2 clocks on a random slope for the daily discrimination–negative affect relation, adjusting for covariates. In line with our baseline model wherein discrimination was associated with more negative affect at the within-person level, the mean value for the slope was significantly positive ($B = 0.15$, 95% CI [0.09, 0.21]). The slope showed significant variability ($B = 0.04$, 95% CI [0.02, 0.07]), suggesting that adults reported more negative affect following discrimination on some days than on other days. After we regressed both clocks on this slope, we found that adults who reported stronger within-person relations between discrimination and negative affect showed more accelerated biological aging in the DunedinPACE clock ($B = 1.83$, 95% CI [0.34, 4.30]) but not in the GrimAge2 clock ($B = 0.95$, 95% CI [−0.52, 2.82]) than did adults who reported weaker within-person relations between discrimination and negative affect.

Sensitivity Analysis

We conducted supplemental analyses to understand the contours of our results. First, to assess the temporal ordering between our constructs, we tested whether the DunedinPACE and GrimAge2 clocks were associated with the discrimination–negative affect slope among 275 adults who completed daily diaries after their Biomarker Project participation. In Table S3, neither of the epigenetic clocks was not significantly related to the slope, evincing the temporal ordering between our constructs.

Second, considering the representation of stigmatized versus nonstigmatized social groups based on race/ethnicity, sex, and sexual orientation, we tested whether our results were specific to social groups most vulnerable to experiencing discrimination. We conducted multigroup analyses in which we tested whether we could constrain the main effect of the latent discrimination–negative affect slope on each clock to be equivalent between a stigmatized versus a nonstigmatized social group. Three independent multigroup analyses were conducted for race/ethnicity (i.e., adults of color versus non-Latinx White adults), sex (i.e., female versus male adults), and sexual orientation (sexual minority versus heterosexual adults). Each social category was rotated one at a time to be a grouping variable followed by Wald chi-square tests comparing the model fit for one model in which the aforenoted main effects on each clock were constrained to be invariant between each group relative to a model in which these main effects were allowed to be freely estimated for each group. Due to software-specific limitations regarding the implementation of multigroup analyses in a two-level Bayesian framework, group comparisons were estimated using maximum-likelihood estimation. Constraining the paths to be equal across groups did not lead to a significant decrease in model fit when examining race/ethnicity, $\chi^2(2) = 0.41$, $p = .82$; sex, $\chi^2(2) = 0.08$, $p = .96$; and sexual orientation, $\chi^2(2) = 1.90$, $p = .39$, suggesting that our main result did not differ by race/ethnicity, sex, or sexual orientation.

Study 2

Study 2 served as a validation assessment due to the large sample size as part of the HRS. Capitalizing on Study 1, we tested the robustness in associations among discrimination, negative affect, and biological age acceleration using five biennial waves among a large sample of adults in retirement.

Methods

Participants and Procedure

Table 1 presents demographic information for the sample of 2,059 adults from the HRS. Of the 2,059 adults, 1,368 adults (or 66% of the sample) self-identified as a social minority, including as an adult of color, female adult, or sexual minoritized adult. The HRS is a nationally representative longitudinal survey of more than 43,000 adults over age 50. To provide data on changing health and economic circumstances in relation to aging, the HRS conducts biennial surveys between 1992 and 2022 on topics such as income, health, cognition, health care, work, retirement, and family. We gathered data from 2008 to 2016, the years when discrimination and negative affect were consistently assessed before venous blood collection in 2016. Epigenetic data were obtained from a subsample who consented to the 2016 Venous Blood Study. Of the 4,018 samples passing quality control, 2,059 adults provided at least one wave of data on our measures between 2008 and 2016 (see the supplemental materials for differences between excluded and included samples). The University of Minnesota's Institutional Review Board deemed the present study not to be human subjects research due to our analysis of de-identified, publicly available data.

Measures

Biological Age Acceleration. In 2016, venous blood samples were collected using EDTA tubes, frozen for storage, and subject to DNA extraction. DNA was tested for suitable yield and integrity before genome-wide methylation profiling using the Illumina Methylation EPIC microarray. After standard quality control protocols, 4,018 methylation profiles were scored using previously published algorithms to compute biological age, including the DunedinPACE (Belsky et al., 2022) and GrimAge2 clocks (Lu et al., 2022). More information on data collection and the derivation of biological age in HRS is available on the HRS Portal (https://hrs.isr.umich.edu). After we regressed the GrimAge2 clock on chronological age to obtain a residual score for biological age acceleration, we standardized the DunedinPACE and GrimAge2 clocks among the full sample of 4,018 adults and found evidence of construct validity (see the supplemental materials for details) before restricting our inferential models among our analytic sample of 2,059 adults. High DunedinPACE and GrimAge2 values reflected more accelerated biological aging.

Table 3

Multilevel Structural Equation Models Among 397 Adults in the Midlife in the United States (MIDUS) Study

	Model 1						Model 2			
	Negative affect (NA)		DunedinPACE		GrimAge2		DunedinPACE		GrimAge2	
Predictors	Estimate (*SD*)	95% CI	Estimate (*SD*)	95% CI	Estimate (SD)	95% CI	Estimate (*SD*)	95% CI	Estimate (*SD*)	95% CI
Level 1: Within-person fixed effects										
Day	−0.01 (0.00)*	[−0.02, −0.01]								
Weekend	−0.04 (0.01)*	[−0.06, −0.02]								
Prior-day NA	−0.03 (0.02)	[−0.06, 0.00]								
Discrimination	0.16 (0.02)*	[0.12, 0.21]								
Level 2: Between-person fixed effects										
Black adults	−0.04 (0.06)	[−0.16, 0.08]	0.64 (0.19)*	[0.26, 1.02]	0.54 (0.18)*	[0.19, 0.89]	0.65 (0.19)*	[0.28, 1.03]	0.54 (0.18)*	[0.19, 0.88]
Latinx adults	0.07 (0.07)	[−0.06, 0.20]	0.32 (0.22)	[−0.10 0.75]	0.33 (0.20)	[−0.06, 0.73]	0.37 (0.21)	[−0.04, 0.81]	0.36 (0.20)	[−0.02, 0.74]
Other adults	−0.05 (0.05)	[−0.15, 0.05]	0.38 (0.17)*	[0.05, 0.71]	0.22 (0.15)	[−0.08, 0.52]	0.38 (0.17)*	[0.04, 0.71]	0.23 (0.15)	[−0.08, 0.53]
Male adults	−0.05 (0.03)	[−0.11, 0.01]	0.05 (0.09)	[−0.13, 0.22]	0.28 (0.08)*	[0.12, 0.44]	0.03 (0.09)	[−0.14, 0.21]	0.27 (0.08)*	[0.11, 0.43]
Sexual minority adults	0.08 (0.06)	[−0.03, 0.19]	0.29 (0.18)	[−0.06, 0.64]	0.30 (0.17)	[−0.02, 0.64]	0.30 (0.18)	[−0.06, 0.66]	0.31 (0.17)	[−0.02, 0.65]
High school or equivalent	0.06 (0.10)	[−0.13, 0.26]	0.03 (0.32)	[−0.57, 0.67]	0.10 (0.29)	[−0.45, 0.68]	0.03 (0.33)	[−0.61, 0.66]	0.10 (0.30)	[−0.50, 0.68]
Some college years	0.15 (0.10)	[−0.05, 0.34]	−0.03 (0.31)	[−0.64, 0.60]	−0.15 (0.29)	[−0.70, 0.41]	0.00 (0.32)	[0.64, 0.63]	−0.14 (0.29)	[−0.77, 0.36]
College or advanced	0.05 (0.10)	[−0.14, 0.25]	−0.26 (0.31)	[−0.85, 0.36]	−0.20 (0.28)	[−0.74, 0.36]	−0.25 (0.31)	[−0.86, 0.36]	−0.21 (0.29)	[−0.77, 0.36]
Chronological age	−0.01 (0.00)*	[−0.01, −0.01]	0.02 (0.00)*	[0.01, 0.03]	0.00 (0.00)	[−0.01, 0.00]	0.02 (0.00)*	[0.01, 0.03]	0.00 (0.00)	[−0.01, 0.01]
Smoking	0.04 (0.03)	[−0.02, 0.09]	0.49 (0.09)*	[0.31, 0.67]	0.78 (0.08)*	[0.61, 0.94]	0.49 (0.09)*	[0.31, 0.67]	0.77 (0.08)*	[0.61, 0.94]
Between-project time lag	0.01 (0.01)	[−0.02, 0.04]	0.03 (0.05)	[−0.06, 0.12]	−0.10 (0.04)*	[−0.18, −0.01]	0.03 (0.05)	[−0.06, 0.12]	−0.10 (0.04)*	[−0.19, −0.01]
Discrimination	0.11 (0.03)*	[0.04, 0.18]	0.31 (0.18)	[−0.05, 0.66]	0.35 (0.17)*	[0.02, 0.67]	−0.06 (0.12)	[−0.28, 0.17]	0.02 (0.11)	[−0.18, 0.23]
Negative affect			−0.07 (0.11)	[−0.29, 0.14]	0.01 (0.10)	[−0.18, 0.21]	0.19 (0.31)	[−0.53, 0.70]	0.29 (0.23)	[−0.21, 0.70]
Discrimination → NA							1.83 (1.04)*	[0.34, 4.30]	0.95 (0.79)	[−0.52, 2.82]
Intercepts	0.14 (0.10)	[−0.05, 0.34]	−0.27 (0.31)	[−0.90, 0.33]	−0.70 (0.29)*	[−1.27, −0.12]	−0.59 (0.36)	[−1.34, 0.08]	−0.66 (0.31)*	[−1.29, −0.06]
Random effects										
Within-person residual	0.05 (0.00)*	[0.04, 0.05]								
Between-person residual	0.06 (0.00)*	[0.05, 0.07]	0.69 (0.05)*	[0.60, 0.80]	0.59 (0.04)*	[0.51, 0.68]	0.58 (0.10)*	[0.36, 0.74]	0.55 (0.06)*	[0.43, 0.66]

Note. Significance is determined by whether the 95% confidence interval (CI) includes zero; the posterior standard deviation reflects uncertainty in estimated parameters (similar to standard errors in frequentist statistics).

* $p < .05$.

Negative Affect. Biennially between 2008 and 2016, adults completed the negative affect items derived from the Positive and Negative Affect Schedule–Expanded Form (Watson & Clark, 1994; i.e., 12-item; e.g., *During the past 30 days, to what degree did you feel . . . sad?*; 1 = *very much*, 5 = *not at all* α-range$_{wave}$ = .88–.91).[1] After reverse coding the items, we computed a mean score across the 12 items at each wave so that high values on each mean score reflected more negative emotions.

Daily Discrimination. Biennially between 2008 and 2016, adults completed the Daily Discrimination Scale (Williams et al., 1997). Using 6-point Likert scales (1 = *never*, 6 = *almost every day*), adults reported their daily experiences in an unspecified timeframe (i.e., six item; e.g., *In your day-to-day life, how often have any of the following things happened to you?—You were treated with less respect than other people?* α-range$_{wave}$ = .81–.84). The measure was not skewed (skewness = 1.59) and evinced concurrent and divergent validity in the supplemental materials. After items were averaged, high values indicated more frequent discrimination.

Covariates. Time-varying covariates included time (range = 0–4) and prior-wave negative affect. Time-invariant covariates included race/ethnicity (i.e., non-Latinx Black: 0 = non-Latinx White, 1 = non-Latinx Black; Latinx: 0 = non-Latinx White, 1 = Latinx, non-Latinx multiracial: 0 = non-Latinx White, 1 = non-Latinx multiracial), sex (0 = *female*, 1 = *male*), sexual orientation (0 = *heterosexual*, 1 = *sexual minority*), chronological age (range = 42–92), smoking (i.e., *Have you ever smoked cigarettes?* 0 = *no*, 1 = *yes*), and educational attainment (i.e., three categorical variables referencing adults with less than a high-school equivalent degree). Blood cell type composition as time-invariant covariates did not change our results (see Table S4).

Missing Data

Among the 2,059 adults, 68% of them participated in all five waves; 29% of them participated in four of the five waves; 2% of them participated in three of the five waves; and 1% of them participated in two of the five waves. On average, adults who completed more waves were more likely to be non-Latinx White adults than adults of color, $F(3, 2054) = 44.31$, $p < .001$, to be older in chronological age ($r = .53$, $p < .001$), and unlikely to have smoked, $t(1081) = 6.85$, $p < .001$. No significant relations emerged between number of waves completed and sex, $t(2009) = 1.53$, $p = .13$; sexual orientation, $t(1341) = 1.22$, $p = .22$; and education attained, $F(3, 2045) = 2.47$, $p = .06$. After adjusting for demographic differences, semipartial correlations illustrated no significant relations between the number of waves completed and the DunedinPACE clock ($r_{sp} = .05$, $p = .08$), the GrimAge2 clock ($r_{sp} = .01$, $p = .69$), negative affect ($r_{sp} = -.04$, $p = .10$), and discrimination ($r_{sp} = -.04$, $p = .19$). Our data were characterized as MAR (Enders, 2025) and were handled with Bayesian full-information Markov chain Monte Carlo estimation (Asparouhov & Muthén, 2021).

Analytic Plan

In Mplus Version 9 (Muthén & Muthén, 1998), two identical multilevel structural equation models as those in Study 1 were estimated, accounting for five biennial waves nested among 2,059 adults and justified by ICCs in Table S1 in the supplemental materials (Hamaker & Muthén, 2020). The ICC for discrimination was .58, suggesting that more than half of the variance was attributed to stable between-person differences.

Results

Tables 1 and 2 present descriptive statistics for and zero-order bivariate correlations among our key constructs, respectively. Across 9 years, 1,569 (76% of the sample) adults reported at least one instance of discrimination. The frequency of discrimination was associated with greater negative affect at the within-person level ($r = .42$, $p < .01$) but was not significantly associated with the DunedinPACE ($r = .01$, $p = .83$) or GrimAge2 ($r = .01$, $p = .83$) clocks at the between-person level.

The Main Effect of Discrimination on Negative Affect

The left side of Table 4 presents a model examining the relations between discrimination and negative affect, adjusting for time-variant and -invariant covariates. On average, adults reported more negative affect in waves when they reported more discrimination relative to waves when they reported less discrimination ($B = 0.16$, 95% CI [0.12, 0.19]).

The Slope for Discrimination and Negative Affect Is Associated With Accelerated Biological Aging

The right portion of Table 4 presents a model regressing the DunedinPACE and GrimAge2 clocks on the slope between discrimination and negative affect, adjusting for covariates. Consistent with the baseline model, the slope has a significantly positive mean value ($B = 0.16$, 95% CI [0.13, 0.19]). The slope showed significant variability ($B = 0.07$, 95% CI [0.06, 0.12]), suggesting considerable within-person variability in the amount of negative affect adults reported following discrimination encounters. Regressing the DunedinPACE and GrimAge2 clocks on this slope revealed that adults with stronger within-person discrimination–negative affect associations showed more accelerated biological aging in the DunedinPACE ($B = 2.60$, 95% CI [2.01, 2.99]) and GrimAge2 clocks ($B = 2.45$, 95% CI [1.94, 2.92]) than did adults who reported weaker within-person discrimination–negative affect associations.

Sensitivity Analysis

We conducted a similar robustness check in Study 2 as we did in Study 1. To assess the temporal ordering between key constructs in our inferences, we noted that the HRS followed adults after their venous blood draws in 2018, 2020, and 2022. With these longitudinal data and to provide evidence of the temporal ordering in our inferences, we tested whether adults' biological age acceleration in 2016 was associated with the random slope for the relation between discrimination and negative affect across 2016, 2018, 2020, and 2022. In Table S5 in the supplemental materials, discrimination continued to predict greater same-wave

[1] R_{Change} indices are primarily used in intensive longitudinal designs, because such indices require frequent repeated measurements with short time intervals. R_{Change} indices in nonintensive longitudinal designs risk misestimating reliability due to few repeated assessments (McAleavey, 2024). Nonetheless, Cronbach's αs are reported.

Table 4

Multilevel Structural Equation Models Among 2,059 Adults in the Health and Retirement Study

	Model 1						Model 2			
	Negative affect (NA)		DunedinPACE		GrimAge2		DunedinPACE		GrimAge2	
Predictors	Estimate (*SD*)	95% CI	Estimate (*SD*)	95% CI	Estimate (*SD*)	95% CI	Estimate (*SD*)	95% CI	Estimate (*SD*)	95% CI
Level 1: Within-person fixed effects										
Wave	−0.02 (0.01)*	[−0.04, −0.01]								
Prior-wave NA	−1.34 (0.53)*	[−2.36, −0.23]								
Discrimination	0.16 (0.02)*	[0.12, 0.19]								
Level 2: Between-person fixed effects										
Non-Latinx Black adults	−0.04 (0.02)*	[−0.08, −0.01]	0.26 (0.03)*	[0.20, 0.32]	0.15 (0.03)*	[0.09, 0.21]	0.27 (0.02)*	[0.22, 0.32]	0.16 (0.03)*	[−0.11, 0.21]
Latinx adults	0.00 (0.01)	[−0.02, 0.02]	0.06 (0.02)*	[0.01, 0.11]	−0.05 (0.02)*	[−0.09, −0.01]	0.06 (0.02)*	[0.01, 0.10]	−0.05 (0.02)	[−0.11, 0.01]
Non-Latinx Other adults	0.02 (0.02)	[−0.02, 0.05]	−0.03 (0.03)	[−0.09, 0.04]	−0.01 (0.03)	[−0.08, 0.04]	−0.03 (0.03)	[−0.09, 0.02]	−0.02 (0.03)	[−0.07, 0.03]
Male adults	−0.17 (0.02)*	[−0.22, −0.13]	0.16 (0.04)*	[0.08, 0.25]	0.46 (0.04)*	[0.39, 0.55]	0.14 (0.04)*	[0.05, 0.21]	0.44 (0.04)*	[0.35, 0.51]
Sexual minority adults	−0.01 (0.06)	[−0.13, 0.10]	0.08 (0.11)	[−0.13, 0.30]	0.10 (0.10)	[−0.11, 0.30]	0.05 (0.11)	[−0.15, 0.21]	0.06 (0.11)	[−0.15, 0.26]
High school or equivalent	−0.05 (0.03)	[−0.12, 0.01]	−0.24 (0.06)*	[−0.35, −0.12]	−0.23 (0.06)*	[−0.35, −0.12]	−0.23 (0.06)*	[−0.36, −0.12]	−0.23 (0.06)*	[−0.36, −0.12]
Some college years	−0.07 (0.04)*	[−0.14, −0.01]	−0.32 (0.06)*	[−0.44, −0.19]	−0.26 (0.06)*	[−0.38, −0.15]	−0.37 (0.06)*	[−0.48, −0.27]	−0.30 (0.06)*	[−0.42, −0.21]
College or advanced	−0.06 (0.04)	[−0.13, 0.01]	−0.48 (0.07)*	[−0.61, −0.35]	−0.52 (0.06)*	[−0.64, −0.39]	−0.53 (0.07)*	[−0.64, −0.40]	−0.55 (0.06)*	[−0.69, −0.42]
Chronological age	−0.01 (0.00)*	[−0.01, −0.01]	0.02 (0.00)*	[0.01, 0.02]	0.01 (0.00)*	[0.01, 0.02]	0.02 (0.00)*	[0.01, 0.02]	0.01 (0.00)*	[0.01, 0.01]
Smoking	0.10 (0.03)*	[0.04, 0.15]	0.53 (0.05)*	[0.43, 0.62]	1.07 (0.04)*	[0.98, 1.16]	0.52 (0.04)*	[0.43, 0.59]	1.06 (0.04)*	[0.98, 1.15]
Discrimination	0.41 (0.02)*	[0.38, 0.45]	0.01 (0.04)	[−0.07, 0.09]	−0.02 (0.04)	[−0.09, 0.06]	0.07 (0.04)	[0.00, 0.13]	0.04 (0.03)	[−0.02, 0.12]
Negative affect			0.04 (0.06)	[−0.08, 0.16]	0.00 (0.06)	[−0.11, 011]	−0.11 (0.07)	[−0.29, 0.00]	−0.15 (0.06)*	[−0.31, −0.06]
Discrimination → NA							2.60 (0.29)*	[2.01, 2.99]	2.45 (0.29)*	[1.94, 2.92]
Intercepts	1.87 (0.04)*	[1.80, 1.94]	−0.01 (0.13)	[−0.26, 0.25]	−0.01 (0.12)	[−0.25, 0.23]	−0.13 (0.17)	[−0.43, 0.24]	−0.10 (0.15)	[−0.33, 0.26]
Random effects										
Within-person residual	0.15 (0.01)*	[0.14, 0.17]								
Between-person residual	0.17 (0.01)*	[0.15, 0.19]	0.85 (0.03)*	[0.80, 0.91]	0.77 (0.02)*	[0.72, 0.81]	0.35 (0.02)*	[0.30, 0.39]	0.32 (0.02)*	[0.28, 0.38]

Note. Significance is determined by whether the 95% confidence interval (CI) includes zero; the posterior standard deviation reflects uncertainty in estimated parameters (similar to standard errors in frequentist statistics).

* $p < .05$.

negative affect at Level 1, but this Level 1 association modeled at Level 2 was not significantly associated with either the DunedinPACE or GrimAge2 clock, justifying the temporal ordering between key constructs.

We also assessed whether our results differed by race/ethnicity, sex, or sexual orientation, using multigroup analyses under consistent estimation settings as those in Study 1. Our main results did not differ by sex, $\chi^2(2) = 2.66$, $p = .26$, or sexual orientation, $\chi^2(2) = 5.03$, $p = .08$. However, when race/ethnicity was used as a grouping category, there was a significant decrement in model fit, $\chi^2(2) = 6.40$, $p < .05$, suggesting that the effect of this slope on each clock significantly differed between adults of color versus non-Latinx White adults. The effect of the slope on each clock was significant for adults of color (DunedinPACE: $B = 6.06$, 95% CI [0.95, 10.36]; GrimAge2: $B = 8.11$, 95% CI [1.14, 13.96]) but was not significant for non-Latinx White adults (DunedinPACE: $B = -9.50$, 95% CI [−21.12, 2.13]; GrimAge2: $B = -9.14$, 95% CI [−20.66, 2.39]).

Transparency and Openness Statement

We have reported how we determined our sample size and all measures in Studies 1 and 2, and we follow Journal Article Reporting Standards (JARS; Kazak, 2018). Neither Study 1 or 2 was preregistered. Data and study materials are publicly available for Studies 1 and 2 via the MIDUS Data Archive and the Health and Retirement Data Archive, respectively.

Discussion

Weathering is a multistage and multilevel process, as chronic threatening situations may deteriorate biological stress systems and healthy development (Geronimus, 2023). To capture how chronic stressful events may accumulate over time to accelerate one's biological age, the present study used two national and longitudinal samples of adults in the United States to initially examine whether discrimination was associated with more negative affect. Our primary goal was to examine whether the strength of this association between discrimination and negative affect accumulated over time to correlate with accelerated biological aging in the DunedinPACE and GrimAge2 clocks.

We found that the strength of the association between discrimination and negative affect was prospectively associated with accelerated biological aging across both samples. In the MIDUS study, participants reporting greater discrimination-linked negative-affect reactivity exhibited accelerated biological aging for only the DunedinPACE clock, whereas significant associations were observed for both DunedinPACE and GrimAge2 in the HRS. This inconsistency, which is not uncommon in studies examining epigenetic clocks (Crimmins et al., 2021), may be due to greater variability in biological age acceleration among the older HRS sample and underlying differences in how each clock was developed. The DunedinPACE clock was trained to predict the rate of physiological decline across organ systems, whereas GrimAge2 was trained to predict mortality risk—an outcome that may require longer, more cumulative discrimination exposure and be less sensitive to brief windows of situational variability, as was observed in the MIDUS 8-day daily diary study. The MIDUS study captured discrimination-linked negative-affect reactivity between 0.25 and 4.67 years before biological aging assessments, whereas the HRS captured this relationship over a 9-year period, reflecting closer alignment with weathering frameworks and the accumulation of biological risk in response to chronic discrimination exposure. We also observed larger effect sizes in the HRS, which, combined with the complementary temporal designs of each study, corroborates the weathering hypothesis and suggests that the biological risks associated with discrimination-linked negative-affect reactivity may accumulate over the life course. Justifying our analytic framework, the frequency of discrimination was not significantly related to biological aging across both studies, which is in line with prior studies that documented associations that were not significant between discrimination and epigenetic aging (Cuevas et al., 2024; Dhingra et al., 2025) and telomere lengths (Lawrence et al., 2022). Advancing this line of research, the present study highlights the critical role of negative-affect reactivity in the association between discrimination and accelerated biological aging at a particular moment in time.

Our findings also suggest that associations between discrimination-linked emotional reactivity and accelerated biological aging may vary by race/ethnicity, with stronger associations observed in adults of color compared with their non-Latinx White counterparts. However, we only observed significant racial/ethnic differences in HRS and not the MIDUS sample, likely due to decreased statistical power given the low proportion of African Americans in the MIDUS sample ($n = 21$) compared with the larger HRS validation cohort ($n = 346$). We acknowledge the limited racial/ethnic diversity in the NSDE-II of the MIDUS study in the supplemental materials, along with evidence indicating potential selection bias, as the analytic sample generally reflected non-Latinx White adults and adults with more years in school.

We did not find significant differences in associations by sex and sexual orientation, which may be attributable to measurement. The present daily discrimination measure originated from a sample of African Americans (Williams et al., 1997), and daily discrimination experiences among African Americans may not generalize to other marginalized social groups, as covert experiences linked to stereotypes about criminality (e.g., "People act as if they are afraid of you.") may not apply to other marginalized social groups (e.g., women, sexual minorities). Indeed, as we found in our validity assessments, daily discrimination was reported more frequently among Black adults but did not significantly vary by adults' sex or sexual orientation.

Limitations, Strengths, and Conclusion

The present study included limitations. First, the daily discrimination measure was initially developed among African American samples (Williams et al., 1997) and may not reflect the experiences of other marginalized social groups (Bastos & Harnois, 2020). Second, we focused on two epigenetic clocks, which reflect a single modality of accelerated biological aging, suggesting that studies should consider replicating our analyses using other indicators of premature aging, including pubertal timing in adolescence (Del Toro, Anderson, et al., 2024; Del Toro et al., 2026) and menopause in adult-aged women (McKnight et al., 2011). Third, although we provided some evidence of temporal ordering between our key constructs, we did not have two or more waves of epigenetic clocks to fully rule out whether accelerated biological aging may have contributed to heightened vulnerability to discrimination.

Fourth, neither the MIDUS study nor the HRS had the PCPhenoAge clock, suggesting future researchers should examine whether our findings replicate using other third-generation epigenetic clocks. Last, participants, particularly in Study 1, underreported perceived attributions of discrimination across social categories, including race ($n = 3$), ethnicity/nationality ($n = 4$), gender ($n = 10$), and sexual orientation ($n = 1$). Although these underreports are in line with prior studies (Williams, 2016), such skewed responses precluded us from including attributions of discrimination in our inferential models.

The present study has strengths with implications for interventions. We used preferred algorithms to assess accelerated biological aging across two national longitudinal samples. The complementary temporal design of both studies—capturing daily reactivity in MIDUS and cumulative burden across years in the HRS—advances a literature that primarily examines epigenetic clocks cross-sectionally (Del Toro, Martz, et al., 2024). To contribute to this literature, we utilize time nested within individuals to assess how time-varying situations shape between-person differences in accelerated biological aging. Identifying individuals who exhibit strong positive associations between discrimination and negative emotions may help practitioners target those most vulnerable to experience accelerated biological aging. By intervening on stress reactivity, programs could more precisely mitigate the physiological wear and tear that contributes to biological aging and have a targeted approach to promoting long-term health among marginalized populations.

Recent advances in biomarker science have deepened our understanding of how discrimination "gets under the skin" and shapes age-related health risks through epigenetic pathways. The current study leverages these innovative measures, finding that greater negative affect stemming from discrimination exposure is associated with accelerated biological aging among multiple national samples of adults. Taken together, results from this study suggest that discrimination-related negative affect is a more robust correlate of biological aging than discrimination frequency, improving precision in understanding weathering processes across the life course and informing health disparities research.

Abstracto

Objetivo: Las respuestas psicológicas crónicas al estrés derivado de la discriminación podrían asociarse con ritmos más acelerados de envejecimiento biológico durante un periodo de tiempo específico a través de cambios epigenéticos en la metilación del ADN, incluyendo aquellos detectados por los relojes epigenéticos de tercera generación (es decir, DunedinPACE y GrimAge2). Si bien la discriminación suele medirse en términos de frecuencia, son escasos los estudios que examinan de qué manera su carga psicológica acumulada se asocia con la aceleración de la edad biológica; una proposición teórica que se alinea con la hipótesis del desgaste. ***Métodos:*** El presente estudio analizó datos de dos estudios longitudinales nacionales: 397 adultos que completaron ocho diarios diarios en el Estudio de La Mediana Edad en los Estados Unidos ("Midlife in the United States" o MIDUS, por sus siglas en inglés) y 2,059 adultos que completaron cinco encuestas bienales en el Estudio de Salud y Retiro (HRS, por sus siglas en Inglés). Modelamos las asociaciones intraindividuales (es decir, las pendientes) entre la discriminación y el afecto negativo, como correlatos del envejecimiento biológico captado por los relojes DunedinPACE y GrimAge2. ***Resultados:*** En ambos estudios, los adultos que experimentaron una mayor discriminación, en promedio, informaron un mayor afecto negativo. Las pendientes positivas más pronunciadas entre la discriminación y el afecto negativo se asociaron con un ritmo de envejecimiento biológico más acelerado en el momento de la evaluación, específicamente en el reloj DunedinPACE dentro del estudio MIDUS, y en los relojes DunedinPACE y GrimAge2 dentro del estudio HRS. Estas asociaciones persistieron tras ajustar por la frecuencia de la discriminación, lo que subraya la importancia de modelar la reactividad al estrés en lugar de la exposición por sí sola. ***Conclusiones:*** Los hallazgos respaldan la hipótesis del desgaste, sugiriendo que las emociones negativas acumuladas vinculadas a la discriminación se relacionan con un envejecimiento biológico acelerado. Las investigaciones futuras podrían aprovechar enfoques longitudinales para identificar poblaciones vulnerables y orientar intervenciones destinadas a reducir la incorporación biológica de la discriminación.

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