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Stress-related changes in personality: A longitudinal study of perceived stress and trait pessimism

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ABSTRACT

Although research has shown that certain aspects of personality can change over time, the determinants of such change remain unclear. Stress alters neural dynamics and precipitates disorders that shape personality traits involving negative affectivity. In this study, therefore, we assessed the perceived stress and pessimism levels of 332 young, middle-aged, and older adults for five weeks to examine how levels of stress and pessimism change and interrelate over time. The best fitting longitudinal model was a bivariate latent growth curve model, which indicated that stress and pessimism both changed and exhibited significant variability in change over time. Moreover, changes in stress were associated with changes in pessimism. Pessimism thus changes over time, with alterations in stress potentially structuring these changes.

1. Introduction

Early research on personality largely conceptualized personality traits as relatively stable constructs that do not readily change over time (Costa & McCrae, 1988). In contrast with this historical view of personality, however, studies of personality occurring over the past few decades have produced substantial evidence that personality can change across time and development (e.g., Bleidorn, 2012; Bleidorn, Kandler, Riemann, Angleitner, & Spinath, 2009; Helson & Wink, 1992; Jayawickreme & Blackie, 2014; Roberts & Mroczek, 2008; Roberts, Walton, & Viechtbauer, 2006; Robins, Fraley, Roberts, & Trzesniewski, 2001). For example, in an influential meta-analysis of mean-level changes in personality traits across time, Roberts et al. (2006) found that social dominance, agreeableness, conscientiousness, and openness to experience increase from younger to upper-middle age in adulthood, whereas social vitality and neuroticism decrease over that same time period. Research has also shown that personality can fluctuate across shorter timescales than years (Fleeson, 2001; Fleeson & Jayawickreme, 2015), with within-person changes in personality potentially occurring over days and representing more than just fluctuations in affect (Wilson, Thompson, & Vazire, 2016). Because changes in personality traits such as neuroticism and conscientiousness predict subsequent changes in health (Magee, Heaven, & Miller, 2013; Turiano et al., 2012) and even mortality (Mroczek & Spiro, 2007), it is important to understand factors that contribute to changes in personality over time. To date, however, these factors remain largely unknown.

Psychological stress is one process that may play a role in shaping personality, especially aspects of personality involving negative affectivity. Stressors are circumstances or situations that are perceived as threatening or challenging, or that exceed a person's ability to cope (Allen, Kennedy, Cryan, Dinan, & Clarke, 2014; Monroe & Slavich, 2016). Exposure to a stressor elicits subjective feelings of stress as well as a biological reaction known as the *stress response*, which includes upregulation of the hypothalamic–pituitary–adrenal axis, sympathetic nervous system, and innate immune system (Allen et al., 2014; Dickerson & Kemeny, 2004; Slavich, O'Donovan, Epel, & Kemeny, 2010; Steptoe, Hamer, & Chida, 2007). The characteristics that stressors possess can be important factors influencing

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the effects that such experiences have on individuals, but these effects are ultimately mediated by individuals' *stress appraisal* (Slavich & Cole, 2013). As an example, stressors perceived as highly threatening have been shown to trigger strong stress responses while those perceived as less threatening do so to a lesser degree (Denson, Spanovic, & Miller, 2009; Gaab, Rohleder, Nater, & Ehlert, 2005; Lebois, Hertzog, Slavich, Feldman Barrett, & Barsalou, 2016).

Time-limited stress responses may not affect health, but stress can also exert sustained effects on neural structure and function, including in brain regions that subserve representations of the self and others, social working memory, and threat perception (McEwen, 2007). As a result, stress has been implicated in the development of several highly recurrent and chronic forms of psychopathology, including anxiety disorders and depression (Slavich & Irwin, 2014), which can promote persistent changes in affective aspects of personality (Klein, Kotov, & Bufferd, 2011). Consistent with a hypothesized link between stress and personality, recent research has shown that major life transitions that occur infrequently over the life course, such as graduating from high school, can prompt changes in personality (e.g., Bleidorn, 2012). It is possible that more frequently occurring stressors, such as stressful interpersonal interactions and unexpected or threatening events, also lead to changes in affective aspects of personality, but to our knowledge this issue has not yet been examined.

The personality trait of pessimism may be particularly likely to be influenced by stress. Pessimism is distinct from optimism (Marshall, Wortman, Kusulas, Hervig, & Vickers, 1992; cf. Kam & Meyer, 2012), and it is possible to be highly pessimistic and highly optimistic at the same time (Benyamini, 2005). Pessimism is positively correlated with neuroticism and inversely correlated with other Big 5 personality traits, such as agreeableness and conscientiousness (Kam & Meyer, 2012). Pessimism in adulthood is predicted by self-esteem in early and late adolescence (Heinonen, Räikkönen, & Keltikangas-Järvinen, 2005), and pessimism is predictive of numerous negative outcomes. For example, trait pessimism predicts delays in recovery following surgery (Bowley, Butler, Shaw, & Kingsnorth, 2003), disruption of social and leisure activities (Carver, Lehman, & Antoni, 2003), poorer quality of life in early-stage breast cancer patients (Carver et al., 1994), signs of biological aging including elevated inflammatory activity and telomere shortening (O'Donovan et al., 2009), and, finally, early mortality (Brummett, Helms, Dahlstrom, & Siegler, 2006; Schulz, Bookwala, Knapp, Scheier, & Williamson, 1996). Understanding how stress affects pessimism should thus be a high priority.

Prior research on links between stress and pessimism has been informative. For example, this work has revealed that levels of stress and pessimism are correlated (McCarthy, Cuskelly, van Kraayenoord, & Cohen, 2006). In addition, at least two studies that employed a common stressor approach found that pessimism levels in adult caregivers of children with attention deficit/hyperactivity disorder (ADHD; Baldwin, Brown, & Milan, 1995) or fragile X syndrome (McCarthy et al., 2006) are associated with the severity of these conditions, with worse ADHD symptoms and behavioral problems in children predicting greater pessimism in caregivers. Data like these suggest that changes in stress may be associated with changes in pessimism over time, but to our knowledge, this question has not been examined.

To address this issue, we recruited a large sample of young, middle-aged, and older adults from the community, and followed them longitudinally over five weeks. We selected this timeframe because daily assessments seemed too close in time for changes in stress to contribute to actual changes (rather than minor fluctuations) in levels of pessimism (cf. Wilson et al., 2016). Monthly assessments of these constructs would have also enabled us to test our hypotheses (below), but the limited resources we had to conduct this study would have only allowed us to perform two monthly assessments, which would not have permitted us to conduct the most appropriate analyses of change. Therefore, each week for five weeks, we assessed participants levels of perceived stress and pessimism, which enabled us to model changes in these two factors over a five-week time period.

Based on the extant research described above, we hypothesized that changes in perceived stress would be associated with changes in pessimism during the five week study period. To test this hypothesis, we fit three models to the data to evaluate different potential patterns of association in the data over time. The models belonged to three classes: cross-lagged regression, multivariate latent growth curve, and multivariate latent difference score models. Cross-lagged regression models assess changes in rank ordering (i.e., relative position of an individual around the average) rather than changes in actual values or scores on a measure over time. Latent growth models assess changes in values over time, rather than assessing changes in rank ordering. Finally, latent difference score models go beyond latent growth curves by assessing both overall rates of change and time point-to-time point change. All of these models, however, allow for an examination of how changes in one variable relate to changes in another variable.

2. Method

2.1. Participants and procedure

To increase the potential for study findings to generalize across a broad age range, we recruited 332 young, middle, and older aged adults (124 male, 208 female) from college campuses and the surrounding community. Participants ranged in age from 16 to 79 years old ($M = 27.9$, $Median = 21$) at the beginning of the study, with the number of individuals per age group listed in Table 1. To recruit this convenience sample, each member of a 34-person research team generated a list of 10 acquaintances and invited them to participate in the study. A total of 340 individuals were thus initially contacted, of which 332 responded to this initial invitation. Each research team member was in turn responsible for sending weekly reminders to their participants to maximize participation and minimize attrition. Using this retention strategy, the number of participants completing Time 1, Time 2, Time 3, Time 4, and Time 5 measures were 327, 298, 287, 273, and 240, respectively. Participants completed the study measures (see below) each week for five consecutive weeks and were instructed to think about the previous week when responding to the items. All participants provided informed consent before beginning the study and all study procedures received Institutional Review Board approval prior to the start of the study.

2.2. Materials

2.2.1. Perceived stress

Participants' levels of perceived stress over the past week were assessed at each time point using the 10-item Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983), which is the most

Table 1
Sample stratified by age.

Age	*N*
16–19	36
20–29	220
30–39	6
40–49	20
50–59	40
60–69	6
70–79	1

widely used instrument for measuring perceived stress. The scale assesses the extent to which a respondent views his or her life as being uncontrollable and unpredictable. An example item is, "During the past week, how often have you been upset because of something that happened unexpectedly?" Participants respond on a 5-point scale, ranging from 0 (*Never*) to 4 (*Very Often*). Internal consistency for the scale in this study was good across all five time-points (all αs $\geqslant$ 0.86).

2.2.2. Pessimism

Participants' levels of trait pessimism were assessed at each time point using the pessimism subscale of the Life Orientation Test-Revised (Scheier, Carver, & Bridges, 1994), which is the most widely used measure of trait pessimism. In contrast to measures that assess state pessimism (e.g., Burke, Joyner, Czech, & Wilson, 2000), this scale is designed to assess the extent to which a person holds a pessimistic disposition. Importantly, however, items on the scale are worded such that participants could reasonably answer differently on a weekly basis (e.g., "If something can go wrong for me, it will"). Participants respond on a 5-point scale, ranging from 0 (*Strongly Disagree*) to 4 (*Strongly Agree*). The Life Orientation Test-Revised has shown good convergent and discriminant validity (Scheier et al., 1994), and internal consistency for the pessimism component of the scale in this study was good across all five time-points (all αs $\geqslant$ 0.82).

2.3. Analytic strategy

To characterize how levels of perceived stress and pessimism changed over the five-week study period and to examine how stress influenced levels of pessimism during this period, we examined the fit of three classes of structural equation models to these data. The three classes of structural equation models included a cross-lagged regression model, a latent growth curve model, and a latent difference score model. Because we only had one scale measuring perceived stress and one scale measuring pessimism, we could not model perceived stress or pessimism as latent variables within each time point.

2.3.1. Cross-lagged regression model

The first model we fit to the data was a cross-lagged regression model (Selig & Preacher, 2009). The cross-lagged regression model examines change over time as a function of rank ordering. Rather than examining the effects of overall changes within scores on a variable, this model examines whether a score on variable X at T − 1 predicts a relatively higher or lower score on variable Y at T. As such, this model is particularly well-suited for variables in which overall mean-level changes are unexpected but fluctuations in scores over time are expected. Consistent with prior research (Hawkley, Thisted, Masi, & Cacioppo, 2010; Kenny, 1975; Little, Preacher, Selig, & Card, 2007) and to allow better comparison with other models, we constrained the stability and cross-paths to be equal over time. This constraint is known as the assumption of stationarity and it statistically helps to allay (but does not entirely alleviate) concerns of third variable influences (Kenny, 1975).

2.3.2. Latent growth curve model

The second model we fit to the data was a latent growth curve model (Ghisletta & McArdle, 2012; Selig & Preacher, 2009). This model presumes that a true score Y is dependent upon both a starting value and time. In a latent growth curve model, the changes modeled are changes in *values*, rather than fluctuations in rank order. This model thus differs from a cross-lagged regression model, which does not examine overall changes. The latent growth curve model is thus a better model to assess changes in the value of a person's score on a variable rather than their rank order. However, a multivariate linear growth curve model cannot examine temporal precedence, as the slope of changes estimated within this model is drawn from changes over the entire time course, and, as such, cannot predict changes in another variable with temporal precedence.

2.3.3. Latent difference score model

The third model we fit to the data was a latent difference score model (Ghisletta & McArdle, 2012; Selig & Preacher, 2009). Like a latent growth curve model, this model estimates overall change. However, this model has the advantage of estimating parameters of incremental change. The change at each time point is then equal to the overall rate of growth plus the preceding score. Thus, when two latent difference score models are estimated concurrently, this model can elucidate whether overall changes in one variable predict overall changes in another, but also whether there is temporal precedence—namely, whether a true score at a given time point (T) predicts changes in another true score at a subsequent time (T + 1). Consistent with prior research (Ghisletta & McArdle, 2012; Grimm, An, McArdle, Zonderman, & Resnick, 2012; Selig & Preacher, 2009), we constrained all stability and coupling parameters to be equal over time.

Like latent growth curve models, latent difference score models examine changes in values rather than changes in rank order. Thus, similar to latent growth curve models, changes in magnitude may be assessed, but the ability to assess these changes comes at the expense of the ability to assess changes in rank order of a variable (fluctuations). Nonetheless, latent difference score models have the advantage over latent growth curve models in that they can address temporal precedence due to fitting both constant change and proportional change parameters.

2.3.4. Data analysis

After examining whether data were missing completely at random, missing data were estimated using full-information maximum likelihood. Analyses were conducted in **R**, version 3.2.0, and structural equation models were fit using the package `lavaan`, version 0.5-20 (Rosseel, 2012).

3. Results

3.1. Preliminary analyses

Descriptive statistics and correlations for all of the observed variables are presented in Table 2.

3.1.1. Missingness analyses

Data were first examined to determine if missing data across the five time points were missing completely at random. Using Little's test for this purpose (Little, 1988), we found no evidence that data were not missing completely at random, $\chi^2(86) = 84.91$, $p = 0.51$. Exploratory analyses of missingness were also conducted for each measured variable to test if the data were missing at random. A series of logistic regressions using a person's score on a given variable (e.g., pessimism, stress) to predict their likelihood of missingness on that same variable at either a prior time or subsequent time were conducted and false discovery rate corrections were applied due to multiple tests. These analyses also indicated that a person's score at a given time point did not predict their likelihood of missing data at any time before or after that time point, $ps > 0.91$.

3.1.2. Longitudinal measurement invariance

Next, we fit a model to assess whether perceived stress and pessimism evidenced longitudinal measurement invariance. This tests whether the same construct is being measured across time and

Table 2
Descriptive statistics and correlation matrix for perceived stress and pessimism across five weeks.

Variable Mean (SD), *N*	1	2	3	4	5	6	7	8	9	10
1. Stress-T1 2.61 (0.60), 327	1									
2. Stress-T2 2.51 (0.64), 299	0.49	1								
3. Stress-T3 2.45 (0.66), 287	0.53	0.64	1							
4. Stress-T4 2.45 (0.67), 273	0.54	0.55	0.59	1						
5. Stress-T5 2.39 (0.66), 241	0.53	0.60	0.66	0.72	1					
6. Pessimism-T1 2.26 (0.88), 328	0.51	0.37	0.41	0.36	0.39	1				
7. Pessimism-T2 2.18 (0.86), 298	0.32	0.56	0.41	0.35	0.39	0.62	1			
8. Pessimism-T3 2.13 (0.91), 287	0.37	0.43	0.57	0.46	0.48	0.67	0.66	1		
9. Pessimism-T4 2.08 (0.86), 272	0.43	0.44	0.45	0.56	0.51	0.63	0.66	0.71	1	
10. Pessimism-T5 2.08 (0.87), 240	0.44	0.49	0.50	0.49	0.52	0.70	0.74	0.81	0.84	1

Note: All correlations were significant at $p < 0.001$.

whether differences are due to measurement issues. The model fit with weak invariance (CFI = 0.982) was not significantly worse than the model with configural invariance (CFI = 0.982), $\chi^2(4) = 3.38$, $p = 0.496$, and the model with strong invariance (CFI = 0.981) was not significantly worse than the model fit with weak invariance, $\chi^2(4) = 6.95$, $p = 0.138$. However, the model with invariances in means (indicating the means of the constructs did not change over time) was a significantly worse fit than the model with strong invariance, $\chi^2(1) = 60.26$, $p < 0.001$. Therefore, although there were differences in means in the constructs over time, longitudinal measurement invariance held for both perceived stress and pessimism in this study, indicating that changes in these constructs were not due to differences in measurement over time.

3.2. Primary analyses

3.2.1. Model fits

For the primary analyses, we fit a cross-lagged regression model, a bivariate latent growth curve model, and a bivariate latent difference score model to the data. Model fit statistics are provided in Table 3. Each model was tested both with the assumption of homogeneity of residual variance being held true and with that assumption being relaxed. All models fit the data significantly better with the assumption of homogeneity of residual variance being relaxed, *ps* < 0.001. As Table 3 illustrates, the best-fitting model was a bivariate latent growth curve model with the assumption of homogeneity of residual variance being relaxed. Because all other models had an |AIC difference| greater than four when comparing their AIC to the AIC of the bivariate latent growth curve model, the bivariate latent growth curve model was a considerably better fit than all of the other models (Burnham & Anderson, 2004). It was not possible to test the fit of this model against the other models using null hypothesis significance testing because these models were not nested. However, all models evidenced adequate fit. Because each model showed adequate fit and provides unique information about how stress relates to changes in pessimism over time, we describe each model below.

3.2.2. Cross-lagged regression modeling of stress and pessimism over time

Because the model with the assumption of homogeneity of residual variance relaxed fit significantly better than the model

Table 3
Fit indices for three longitudinal models estimating relational change in perceived stress and pessimism across five weeks.

Model		CLR	LGC	LDS
Homogeneity of residual variance assumed	*CFI*	0.826	0.977	0.982
	RMSEA	0.140	0.052	0.047
	AIC	4998.1	4726.5	4720.7
Homogeneity of residual variance relaxed	*CFI*	0.885	**0.998**	0.998
	RMSEA	0.132	**0.017**	0.019
	AIC	4904.9	**4699.5**	4703.9

Note: The model with the best fit is represented by boldface font. CLR = cross-lagged regression; LGC = latent growth curve; LDS = latent difference score.

without that assumption relaxed, $\chi^2(12) = 117.29$, $p < 0.001$, we present the results of the relaxed model here. We hypothesized that perceived stress at a preceding time point would predict pessimism at a subsequent time, controlling for pessimism at the preceding time. As hypothesized, the cross-lagged parameter from perceived stress to pessimism was significant, $\beta = 0.083$, $p = 0.012$, indicating that greater perceived stress at a preceding time predicted greater pessimism at a subsequent time. Greater pessimism at a preceding time point also predicted greater perceived stress at a subsequent time, $\beta = 0.124$, $p < 0.001$. In addition, the autoregressive parameters for both perceived stress, $\beta = 0.547$, $p < 0.001$, and pessimism, $\beta = 0.684$, $p < 0.001$, were highly significant, indicating stability in these constructs over time. In sum, this model provides support for a bidirectional association between stress and pessimism, with greater perceived stress at a preceding time point predicting greater pessimism at a subsequent time, and vice versa, controlling for the other construct at a preceding time.

3.2.3. Bivariate latent growth curve modeling of stress and pessimism over time

Table 4 summarizes the means and variances for intercepts and slopes for all of the latent variables that were estimated in the best-fitting bivariate latent growth model and, in addition, presents the correlations between these variables. Because the model with the assumption of homogeneity of residual variance relaxed fit significantly better than the model without that assumption relaxed, $\chi^2(12) = 51.02$, $p < 0.001$, we present the results of the relaxed model here. Using this model, we first examined the role

Table 4
Latent intercepts, slopes, and correlations from a bivariate latent growth model estimating relational change in perceived stress and pessimism across five weeks (assumption of homogeneity of residual variance relaxed).

Parameter	Mean	Variance	x_0	y_0	x_s	y_s
x_0	2.59***	0.500***	1			
y_0	2.24***	0.215***	0.639***	1		
x_s	−0.052***	0.010***	−0.113	−0.006	1	
y_s	−0.045***	0.012***	−0.014	−0.165	0.415*	1

Note: x = perceived stress; y = pessimism; subscript 0 = intercept; subscript s = slope.
* $p \leqslant 0.05$.
*** $p \leqslant 0.001$.

Table 5
Latent intercepts, slopes, and correlations from a latent difference score model estimating relational change in perceived stress and pessimism across five weeks (with assumption of homogeneity of residual variance relaxed).

Parameter	Mean	Variance	x_0	y_0	x_s	y_s
x_0	2.61***	0.502***	1			
y_0	2.26***	0.213***	0.620***	1		
x_s	0.737	0.080	0.347	−0.301	1	
y_s	0.436	0.025	0.475	−0.086	0.740	1

Note: x = perceived stress; y = pessimism; subscript 0 = intercept; subscript s = slope.
*** $p \leqslant 0.001$.

that perceived stress played in shaping pessimism levels over the five-week time period. As hypothesized, the correlation between perceived stress and pessimism at baseline was significant, $r = 0.64$, $p < 0.001$. Although this baseline correlation does not address changes over time, it does provide evidence that perceived stress and pessimism are related. Of note, however, correlations of intercepts with slopes were all non-significant, $|r|\text{s} < 0.17$, *ps* > 0.19, indicating that baseline values of perceived stress or pessimism were not associated with accelerated or decelerated changes over time in either factor.

Statistically significant average changes (i.e., slopes) were observed for both perceived stress and pessimism, indicating that, on average, both perceived stress, $B = -0.052$, $p < 0.001$, and pessimism, $B = -0.045$, $p < 0.001$, decreased over the five-week study period. There was also significant variability in slopes, indicating that individual differences were evident in the extent to which participants exhibited changes in perceived stress, $s^2 = 0.10$, $p < 0.001$, and pessimism, $s^2 = 0.12$, $p < 0.001$, across this time period. Because changes over time differed between individuals, one or more factors likely moderated these changes in perceived stress or pessimism during the five-week study period.

To examine the main research question of how changes in perceived stress relate to changes in pessimism over time, we constrained the covariance between the slope of pessimism and the slope of perceived stress to zero, and estimated a regression path from the slope of perceived stress to the slope of pessimism. This regression path was significant and the association was positive, $\beta = 0.42$, $p = 0.027$, indicating that increases in levels of perceived stress were associated with increases in pessimism over time. In sum, therefore, levels of perceived stress and pessimism were positively associated at baseline and, in addition, changes in perceived stress were strongly associated with changes in pessimism over time.

3.2.4. Bivariate latent difference score modeling of stress and pessimism over time

Table 5 summarizes the constant change slopes and intercepts for the bivariate latent difference score model and presents the correlations between the constant change slopes and intercepts. Because the model with the assumption of homogeneity of residual variance relaxed fit significantly better than the model without that assumption relaxed, $\chi^2(12) = 40.76$, $p < 0.001$, we present the results of the relaxed model here. First, we examined the role that perceived stress played in shaping pessimism levels over the five-week time period (i.e., the constant change). As expected, the correlation of intercepts (i.e., the correlation between perceived stress and pessimism at baseline) was significant, $r = 0.620$, $p < 0.001$. Although this baseline correlation does not address changes over time, it does provide evidence that perceived stress and pessimism are related. Correlations of intercepts with slopes were all non-significant, *ps* > 0.27, indicating that baseline values of stress or pessimism were not associated with accelerated or decelerated changes over time in either factor. Unlike the bivariate latent growth curve model, however, according to this model, there were not statistically significant average changes in either pessimism ($p = 0.446$) or perceived stress ($p = 0.148$) over time. Similarly, the variances of these constant change parameters were not significant (*ps* > 0.352), indicating a lack of variability in the constant changes over time. Of note, this lack of constant linear change differs from the pattern of results evident in Table 2, which clearly show a decrease over time in both constructs. In addition, contrary to expectations, changes in perceived stress were not significantly related to changes in pessimism over the entire five-week period in this model, $r = 0.740$, $p = 0.581$.

Finally, we examined proportional changes within this model. Unexpectedly, however, all of the stability and coupling coefficients were non-significant, *ps* > 0.312, indicating that proportional changes in either perceived stress or pessimism were not predicted by the same construct or the other construct at a preceding time.[1]

4. Discussion

Although many early theories regarded personality as relatively fixed over time, it is now widely appreciated that personality traits can change. Presently, however, the factors that influence changes in personality are not well understood. We aimed to address this issue in the present study by using three classes of statistical models to examine how perceived stress and pessimism change over five weeks and, in addition, how changes in perceived stress are longitudinally associated with changes in pessimism. Model fit statistics indicated that the bivariate latent growth curve model was substantially preferable to the other models, and this model revealed a significant association between changes in perceived stress and changes in pessimism over time. To our knowledge, these data are the first to show that stress is associated with changes in pessimism on a weekly basis.

One notable aspect of these findings involves the differences observed between models. Namely, despite the conceptual agreement between the cross-lagged regression model and the bivariate latent growth curve model, the results of the bivariate latent difference score model differed in several important ways from the other models. First, the latent difference score model showed better fit relative to the cross-lagged regression model but also showed poorer fit than the latent growth model. Second, the bivariate latent difference score model did not estimate any significant linear change in either

[1] We also examined whether age moderated any of the results, but it did not. Namely, age did not moderate the association between the rank-order of stress at a preceding time and the rank-order of pessimism at a subsequent time in the cross-lagged regression model, $p = 0.127$. Similarly, age did not moderate the association between changes in the value of stress and changes in the value of pessimism in the latent growth curve model, $p = 0.846$. Finally, in the latent difference score model, age did not moderate the association between overall changes in stress and overall changes in pessimism, $p = 0.426$, or the association between the values of stress at a preceding time point and the values of pessimism at a subsequent time point, $p = 0.181$.

construct over time, unlike the bivariate latent growth curve model and the observable pattern of change in the raw variables. Third, the bivariate latent difference score model showed no significant associations between changes in perceived stress and changes in pessimism, either in proportional or constant change. This differed from both the bivariate latent growth curve and the cross-lagged regression models, which both showed associations in changes between these constructs over time. The reasons for these discrepancies are unclear, other than simple differences in how the models are specified. At the same time, the lack of association of changes between the variables in the bivariate latent difference score model may not be very meaningful due to the discrepancy between the latent difference score model and the pattern of changes in the observed variables over time (compare the lack of overall change in this model to Table 2) coupled with the conceptual agreement between the other two models. Still, this lack of agreement between this model and the other two models should be considered an opportunity for further research.

Another notable aspect of these findings is that we observed decreases in levels of both perceived stress and pessimism over the five-week study period. Although we can only speculate about potential reasons for these specific patterns of change, it is possible that participating in the study had unintended beneficial effects on individuals' stress levels or that these assessments covered a time period marked by naturally occurring decreases in stress burden. Because the data we collected do not allow us to adjudicate between these or other possibilities, additional research is needed to understand these effects.

Notwithstanding these points, the present findings are consistent with other recent studies showing that changes in personality can occur over a relatively short timeframe. For example, recent research has demonstrated that personality states and behaviors that are indicative of personality states can fluctuate rapidly (Fleeson & Jayawickreme, 2015; Sherman, Rauthmann, Brown, Serfass, & Jones, 2015), potentially even over the course of a day (Wilson et al., 2016), although very short-term fluctuations are generally considered to be centered around a mean that corresponds to a relatively stable trait. Other research has demonstrated that personality traits (Jayawickreme & Blackie, 2014; MacLean, Johnson, & Griffiths, 2011) and consistent patterns of behavior (Penton-Voak et al., 2013) can change within weeks, especially in response to a triggering event (Wrzus & Roberts, 2016). The present data extend this work by providing evidence of mean-level changes in pessimism over a five-week period. Moreover, these changes were associated with changes in, or preceding levels of, perceived stress in bivariate latent growth curve and cross-lagged regression models, respectively. The present results thus add to the growing body of research indicating that changes in personality may occur over a relatively short time, but add to this body of work by showing how perceived stress is associated with such changes in personality.

Consistent with these effects, prior research on the longitudinal dynamics of personality has shown that major life transitions (e.g., Bleidorn, 2012) and stressors (e.g., Boyce, Wood, Daly, & Sedikides, 2015) predict changes in personality over time. The present data are consistent with this research, but extend this work in an important new direction by showing that experiences of non-severe stress are also associated with personality changes over time, specifically with regard to pessimism. Although the effects that non-severe stressors have on personality are likely smaller in magnitude than those associated with major life events, non-severe life stressors occur more frequently than major life events (Brown & Harris, 1978) and may thus have important implications for individuals' levels of pessimism, which are in turn known to affect human health and wellbeing (Maruta, Colligan, Malinchoc, & Offord, 2002; Plomin et al., 1992).

Several limitations of this research should be noted. First, we assessed experiences of stress using a well-validated, self-report measure of subjective stress. Although we believe this strategy represents a valuable first-step for addressing questions on this topic, interview-based systems for assessing life stress have important advantages over self-report instruments and should thus be used in future research on this topic (Monroe, 2008; Monroe & Slavich, 2016). Second, we assessed only one aspect of personality (i.e., pessimism) and it is possible that stress may influence other higher-order personality traits as well, such as conscientiousness and extraversion. Additional research is thus needed to examine the effects of stress on other personality traits. Third, research on post-traumatic growth has shown that major life stressors may lead to personal growth, potentially by influencing the development of positive personality traits (Woodward & Joseph, 2003). Therefore, additional research is warranted to identify when significant life stressors lead to positive versus negative changes in personality and health. Fourth, although we tested associations between stress and pessimism over five consecutive weeks, as with all similar studies, the present data are correlational and do not indicate causation. Fifth, the temporal precedence of changes in stress and pessimism needs to be examined in future research. Although the cross-lagged regression model fit to these data indicated significant temporal effects, it had relatively poorer fit compared to the bivariate growth model. In addition, the analysis regressing pessimism on perceived stress in the bivariate latent growth curve model simply redistributes the variance in the correlation between changes in stress and changes in pessimism into a regression pathway and, consequently, this analysis is no more informative than the correlation between slopes. Indeed, reversing the direction of the regression slope produces a model with an identical fit, as does allowing these changes to covary rather than placing them in a regression. We reported the regression coefficient as such because we had an *a priori* directional hypothesis, but ultimately, future research that manipulates stress (e.g., using a laboratory-based stress task) and examines the effects that such manipulations have on pessimism is needed to evaluate questions about cause and effect.

Finally, the present data cannot rule out the possibility that levels of perceived stress were related to changes in levels of pessimism for reasons not involving the effects of stress. For example, it is possible that perceived stress at one time point is inversely related to psychosocial or other kinds of resources, and that experiencing a lack of these resources is what changes pessimism (rather than the experience of stress *per se*). Future research could address this question by experimentally manipulating stress over time (e.g., by texting participants for one or more weeks and asking them to think about a recent stressful event or difficulty for a few minutes) and then examining the effects that this manipulation has on pessimism. If such studies implicate stress as a primary factor driving increases in pessimism, then additional research should examine the specific mechanisms underlying such effects. For example, stressed individuals may engage in styles of coping that exhaust their psychological resources, thereby leading to pessimism. Or, stress may induce neural or biological changes that promote pessimism, such as increased neural sensitivity to threat or inflammation (Slavich, 2015; Slavich, Way, Eisenberger, & Taylor, 2010). Ultimately, studies examining these and other possibilities are needed to elucidate how stress might lead to changes in pessimism over time.

In conclusion, the present data are the first to show that weekly changes in perceptions of stress are associated with weekly changes in pessimism over time. Although the model that best fit these data cannot address cause or temporal precedence, these findings are the first to show a relation over time between changes in perceived stress and personality. Additional research is needed to determine the temporal ordering of these effects, to examine the effect that stress has on other personality characteristics, to elucidate psychological and biological mechanisms underlying these effects, and to determine the relevance of these stress-personality dynamics for human health.

Conflict of interest

The authors declare that they have no conflicts of interest with respect to their authorship or the publication of this article.

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References

Allen, A. P., Kennedy, P. J., Cryan, J. F., Dinan, T. G., & Clarke, G. (2014). Biological and psychological markers of stress in humans: Focus on the Trier Social Stress Test. *Neuroscience and Biobehavioral Reviews, 38*, 94–124.

Baldwin, K., Brown, R. T., & Milan, M. A. (1995). Predictors of stress in caregivers of attention deficit hyperactivity disordered children. *The American Journal of Family Therapy, 23*, 149–160.

Benyamini, Y. (2005). Can high optimism and high pessimism co-exist? Findings from arthritis patients coping with pain. *Personality and Individual Differences, 38*, 1463–1473.

Bleidorn, W. (2012). Hitting the road to adulthood short-term personality development during a major life transition. *Personality and Social Psychology Bulletin, 38*, 1594–1608.

Bleidorn, W., Kandler, C., Riemann, R., Angleitner, A., & Spinath, F. M. (2009). Patterns and sources of adult personality development: Growth curve analyses of the NEO PI-R scales in a longitudinal twin study. *Journal of Personality and Social Psychology, 97*, 142–155.

Bowley, D. M., Butler, M., Shaw, S., & Kingsnorth, A. N. (2003). Dispositional pessimism predicts delayed return to normal activities after inguinal hernia operation. *Surgery, 133*, 141–146.

Boyce, C. J., Wood, A. M., Daly, M., & Sedikides, C. (2015). Personality change following unemployment. *Journal of Applied Psychology, 100*, 991–1011.

Brown, G. W., & Harris, T. O. (1978). *Social origins of depression: A study of psychiatric disorder in women*. New York, NY: Free Press.

Brummett, B. H., Helms, M. J., Dahlstrom, W. G., & Siegler, I. C. (2006). Prediction of all-cause mortality by the Minnesota Multiphasic Personality Inventory Optimism-Pessimism Scale scores: Study of a college sample during a 40-year follow-up period. *Mayo Clinic Proceedings, 81*, 1541–1544.

Burke, K. L., Joyner, A. B., Czech, D. R., & Wilson, M. J. (2000). An investigation of concurrent validity between two optimism/pessimism questionnaires: The Life Orientation Test-Revised and the optimism/pessimism scale. *Current Psychology, 19*, 129–136.

Burnham, K. P., & Anderson, D. R. (2004). Multimodel inference understanding AIC and BIC in model selection. *Sociological Methods & Research, 33*, 261–304.

Carver, C. S., Lehman, J. M., & Antoni, M. H. (2003). Dispositional pessimism predicts illness-related disruption of social and recreational activities among breast cancer patients. *Journal of Personality and Social Psychology, 84*, 813–821.

Carver, C. S., Pozo-Kaderman, C., Harris, S. D., Noriega, V., Scheier, M. F., Robinson, D. S., ... Clark, K. C. (1994). Optimism versus pessimism predicts the quality of women's adjustment to early stage breast cancer. *Cancer, 73*, 1213–1220.

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24*, 385–396.

Costa, P. T., & McCrae, R. R. (1988). Personality in adulthood: A six-year longitudinal study of self-reports and spouse ratings on the NEO Personality Inventory. *Journal of Personality and Social Psychology, 54*, 853–863.

Denson, T. F., Spanovic, M., & Miller, N. (2009). Cognitive appraisals and emotions predict cortisol and immune responses: A meta-analysis of acute laboratory social stressors and emotion inductions. *Psychological Bulletin, 135*, 823–853.

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin, 130*, 355–391.

Fleeson, W. (2001). Toward a structure- and process-integrated view of personality: Traits as density distributions of states. *Journal of Personality and Social Psychology, 80*, 1011–1027.

Fleeson, W., & Jayawickreme, E. (2015). Whole trait theory. *Journal of Research in Personality, 56*, 82–92.

Gaab, J., Rohleder, N., Nater, U. M., & Ehlert, U. (2005). Psychological determinants of the cortisol stress response: The role of anticipatory cognitive appraisal. *Psychoneuroendocrinology, 30*, 599–610.

Ghisletta, P., & McArdle, J. J. (2012). Latent curve models and latent change score models estimated in R. *Structural Equation Modeling: A Multidisciplinary Journal, 19*, 651–682.

Grimm, K. J., An, Y., McArdle, J. J., Zonderman, A. B., & Resnick, S. M. (2012). Recent changes leading to subsequent changes: Extensions of multivariate latent difference score models. *Structural Equation Modeling: A Multidisciplinary Journal, 19*, 268–292.

Hawkley, L. C., Thisted, R. A., Masi, C. M., & Cacioppo, J. T. (2010). Loneliness predicts increased blood pressure: 5-year cross-lagged analyses in middle-aged and older adults. *Psychology and Aging, 25*, 132–141.

Heinonen, K., Räikkönen, K., & Keltikangas-Järvinen, L. (2005). Self-esteem in early and late adolescence predicts dispositional optimism–pessimism in adulthood: A 21-year longitudinal study. *Personality and Individual Differences, 39*, 511–521.

Helson, R., & Wink, P. (1992). Personality change in women from the early 40s to the early 50s. *Psychology and Aging, 7*, 46–55.

Jayawickreme, E., & Blackie, L. E. (2014). Post-traumatic growth as positive personality change: Evidence, controversies and future directions. *European Journal of Personality, 28*, 312–331.

Kam, C., & Meyer, J. P. (2012). Do optimism and pessimism have different relationships with personality dimensions? A re-examination. *Personality and Individual Differences, 52*, 123–127.

Kenny, D. A. (1975). Cross-lagged panel correlation: A test for spuriousness. *Psychological Bulletin, 82*, 887–903.

Klein, D. N., Kotov, R., & Bufferd, S. J. (2011). Personality and depression: Explanatory models and review of the evidence. *Annual Review of Clinical Psychology, 7*, 269–295.

Lebois, L. A. M., Hertzog, C., Slavich, G. M., Feldman Barrett, L., & Barsalou, L. W. (2016). Establishing the situated features associated with perceived stress. *Acta Psychologica, 169*, 119–132.

Little, R. J. (1988). A test of missing completely at random for multivariate data with missing values. *Journal of the American Statistical Association, 83*, 1198–1202.

Little, T. D., Preacher, K. J., Selig, J. P., & Card, N. A. (2007). New developments in latent variable panel analyses of longitudinal data. *International Journal of Behavioral Development, 31*, 357–365.

MacLean, K. A., Johnson, M. W., & Griffiths, R. R. (2011). Mystical experiences occasioned by the hallucinogen psilocybin lead to increases in the personality domain of openness. *Journal of Psychopharmacology, 25*, 1453–1461.

Magee, C. A., Heaven, P. C., & Miller, L. M. (2013). Personality change predicts self-reported mental and physical health. *Journal of Personality, 81*, 324–334.

Marshall, G. N., Wortman, C. B., Kusulas, J. W., Hervig, L. K., & Vickers, R. R. Jr., (1992). Distinguishing optimism from pessimism: Relations to fundamental dimensions of mood and personality. *Journal of Personality and Social Psychology, 62*, 1067–1074.

Maruta, T., Colligan, R. C., Malinchoc, M., & Offord, K. P. (2002). Optimism-pessimism assessed in the 1960s and self-reported health status 30 years later. *Mayo Clinic Proceedings, 77*, 748–753.

McCarthy, A., Cuskelly, M., van Kraayenoord, C. E., & Cohen, J. (2006). Predictors of stress in mothers and fathers of children with fragile X syndrome. *Research in Developmental Disabilities, 27*, 688–704.

McEwen, B. S. (2007). Physiology and neurobiology of stress and adaptation: Central role of the brain. *Physiological Reviews, 87*, 873–904.

Monroe, S. M. (2008). Modern approaches to conceptualizing and measuring human life stress. *Annual Review of Clinical Psychology, 4*, 33–52.

Monroe, S. M., & Slavich, G. M. (2016). Psychological stressors: Overview. In G. Fink (Ed.), *Stress: Concepts, cognition, emotion, and behavior* (1st ed., pp. 109–115). Cambridge, MA: Academic Press.

Mroczek, D. K., & Spiro, A. (2007). Personality change influences mortality in older men. *Psychological Science, 18*, 371–376.

O'Donovan, A., Lin, J., Dhabhar, F. S., Wolkowitz, O., Tillie, J. M., Blackburn, E., & Epel, E. (2009). Pessimism correlates with leukocyte telomere shortness and elevated interleukin-6 in post-menopausal women. *Brain, Behavior, and Immunity, 23*, 446–449.

Penton-Voak, I. S., Thomas, J., Gage, S. H., McMurran, M., McDonald, S., & Munafò, M. R. (2013). Increasing recognition of happiness in ambiguous facial expressions reduces anger and aggressive behavior. *Psychological Science, 24*, 688–697.

Plomin, R., Scheier, M. F., Bergeman, C. S., Pedersen, N. L., Nesselroade, J. R., & McClearn, G. E. (1992). Optimism, pessimism and mental health: A twin/adoption analysis. *Personality and Individual Differences, 13*, 921–930.

Roberts, B. W., & Mroczek, D. (2008). Personality trait change in adulthood. *Current Directions in Psychological Science, 17*, 31–35.

Roberts, B. W., Walton, K. E., & Viechtbauer, W. (2006). Patterns of mean-level change in personality traits across the life course: A meta-analysis of longitudinal studies. *Psychological Bulletin, 132*, 1–25.

Robins, R. W., Fraley, R. C., Roberts, B. W., & Trzesniewski, K. H. (2001). A longitudinal study of personality change in young adulthood. *Journal of Personality, 69*, 617–640.

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software, 48*, 1–36.

Scheier, M. F., Carver, C. S., & Bridges, M. W. (1994). Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): A reevaluation of the Life Orientation Test. *Journal of Personality and Social Psychology, 67*, 1063–1078.

Schulz, R., Bookwala, J., Knapp, J. E., Scheier, M., & Williamson, G. M. (1996). Pessimism, age, and cancer mortality. *Psychology and Aging, 11*, 304–309.

Selig, J. P., & Preacher, K. J. (2009). Mediation models for longitudinal data in developmental research. *Research in Human Development, 6*, 144–164.

Sherman, R. A., Rauthmann, J. F., Brown, N. A., Serfass, D. G., & Jones, A. B. (2015). The independent effects of personality and situations on real-time expressions of behavior and emotion. *Journal of Personality and Social Psychology, 109*, 872–888.

Slavich, G. M. (2015). Understanding inflammation, its regulation, and relevance for health: A top scientific and public priority. *Brain, Behavior, and Immunity, 45*, 13–14.

Slavich, G. M., & Cole, S. W. (2013). The emerging field of human social genomics. *Clinical Psychological Science, 1*, 331–348.

Slavich, G. M., & Irwin, M. R. (2014). From stress to inflammation and major depressive disorder: A social signal transduction theory of depression. *Psychological Bulletin, 140*, 774–815.

Slavich, G. M., O'Donovan, A., Epel, E. S., & Kemeny, M. E. (2010). Black sheep get the blues: A psychobiological model of social rejection and depression. *Neuroscience and Biobehavioral Reviews, 35*, 39–45.

Slavich, G. M., Way, B. M., Eisenberger, N. I., & Taylor, S. E. (2010). Neural sensitivity to social rejection is associated with inflammatory responses to social stress. *Proceedings of the National Academy of Sciences of the United States of America, 107*, 14817–14822.

Steptoe, A., Hamer, M., & Chida, Y. (2007). The effects of acute psychological stress on circulating inflammatory factors in humans: A review and meta-analysis. *Brain, Behavior, and Immunity, 21*, 901–912.

Turiano, N. A., Pitzer, L., Armour, C., Karlamangla, A., Ryff, C. D., & Mroczek, D. K. (2012). Personality trait level and change as predictors of health outcomes: Findings from a national study of Americans (MIDUS). *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 67*, 4–12.

Wilson, R. E., Thompson, R. J., & Vazire, S. (2016). Are fluctuations in personality states more than just fluctuations in affect? *Journal of Research in Personality*. http://dx.doi.org/10.1016/j.jrp.2016.06.006. Advance online publication.

Woodward, C., & Joseph, S. (2003). Positive change processes and post-traumatic growth in people who have experienced childhood abuse: Understanding vehicles of change. *Psychology and Psychotherapy: Theory, Research and Practice, 76*, 267–283.

Wrzus, C., & Roberts, B. W. (2016). Processes of personality development in adulthood: The TESSERA framework. *Personality and Social Psychology Review*. http://dx.doi.org/10.1177/1088868316652279. Advance online publication.