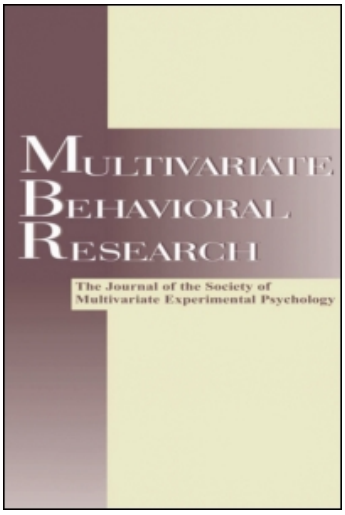

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Multilevel Factor Analysis and Structural Equation Modeling of Daily Diary Coping Data: Modeling Trait and State Variation

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Multilevel Factor Analysis and Structural Equation Modeling of Daily Diary Coping Data: Modeling Trait and State Variation

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This study used multilevel modeling of daily diary data to model within-person (state) and between-person (trait) components of coping variables. This application included the introduction of multilevel factor analysis (MFA) and a comparison of the predictive ability of these trait/state factors. Daily diary data were collected on a large ($n = 366$) multiethnic sample over the course of 5 days. Intraclass correlation coefficient for the derived factors suggested approximately equal amounts of variability in coping usage at the state and trait levels. MFAs showed that Problem-Focused Coping and Social Support emerged as stable factors at both the within-person and between-person levels. Other factors (Minimization, Emotional Rumination, Avoidance, Distraction) were specific to the within-person or between-person levels but not both. Multilevel structural equation modeling (MSEM) showed that the prediction of daily positive and negative affect differed as a function of outcome and level of coping factor. The Discussion section focuses primarily on a conceptual and methodological understanding of modeling state and trait coping using daily diary data with MFA and MSEM to examine covariation among coping variables and predicting outcomes of interest.

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The conceptualization of the coping construct and examination of its underlying structure and function has been investigated at great length over the last several decades (e.g., Aldwin, 2007; Lazarus & Folkman, 1984; Pearlin & Schooler, 1978; Roth & Cohen, 1986; Schwarzer & Schwarzer, 1996; Skinner, Edge, Altman, & Sherwood, 2003). Although theories of coping are becoming more refined, there still remains contention regarding theoretical conceptualizations, structure, and measurement methods (see Aldwin, 2007; Coyne & Racioppo, 2000; Lazarus, 2000; Skinner et al., 2003; Somerfield & McCrae, 2000). Theoretical approaches have been outlined by reviewers such as Aldwin and include some of the following: "Person-based" (or dispositional) orientations that suggest personality characteristics or perceptual styles are central determinants for coping selection (e.g., Cramer, 2000; Roth & Cohen, 1986; Stroebe & Schut, 2001) and "Situational-determinant" orientation that posits individuals select coping strategies according to environmental demands and constraints (e.g., Brown & Harris, 1978; Mattlin, Wethington, & Kessler, 1990; Moos & Schaefer, 1993; Pearlin & Schooler, 1978).

Historically researchers have used two primary measurement approaches to operationally define coping within these general theoretical models. The first approach simply asks individuals how they cope with stress *in general*, whereas the second approach asks individuals how they coped with reference to a *target stressor* (either defined by the researcher or self-identified) at a single timepoint. Subsequent to this, individuals are presented with a list of coping strategies where they indicate usage of each. As Steed (1998) has noted, coping measures (e.g., COPE; Carver, Scheirer, & Weintraub, 1989) simply alter the instructions to go from *dispositional* (how one copes with stress in general) to *situational* (how one copes with a specific stressor). These single timepoint recall assessment methods, however, potentially miss the day-to-day—if not hour-to-hour—variability associated with dynamics of everyday life. Moreover, coping studies have shown that these recall measures correlate very poorly with measures based on Ecological Momentary Assessment/Daily Diary (EMA/DD; Ptacek, Smith, Espe, & Rafferty, 1994; J. E. Schwartz, Neale, Marco, Shiffman, & Stone, 1999; Stone et al., 1998) and are more prone to memory biases and reactive effects (Hufford & Shields, 2002; Hufford & Shiffman, 2002; Stone, Shiffman, Atienza, & Nebeling, 2007; Stone, Shiffman, Schwartz, Broderick, & Hufford, 2003).

To overcome these limitations, daily coping process designs have been proposed and implemented (see Armeli, Todd, & Mohr, 2005; Suls & Martin, 2005, for reviews) using EMA/DD (Shiffman, Stone, & Hufford, 2008) methodology. These paradigms suggest that stress and coping is a dynamic, unfolding process that is best operationalized through repeated assessments of individuals over smaller time frames (e.g., hours to days over multiple days). Through these repeated assessments, EMA/DD allows variability of the stress and coping process (including salient situational characteristics) to be captured in situ and subsequently modeled at the within-person (e.g., daily) and between-person (e.g.,

aggregated across days) levels of analysis. These two sources of variability cannot be simultaneously evaluated when coping is measured at a single timepoint. Moreover, because of the shorter time frames between assessments in EMA/DD, spillover or carryover effects can also be analyzed. It is very common in studies such as these to find stressors, coping strategies, and affective states on a target day, for example, that are still influential the next day and beyond (Suls & Martin, 2005). Although EMA/DD does not completely reduce recall biases inherent in the two approaches historically used, this approach does reduce the recollection window in reporting on target variables, thus reducing measurement error.

Using multilevel modeling with data from an EMA/DD design allows researchers to capture moment-to-moment coping activities and model this within-person (co)variability (akin to a "state") while at the same time estimating reliable between-person variability (akin to a "trait"). The aggregation of within-person assessments across time reduces error relative to single assessments and provides a more statistically reliable and powerful measure of the construct(s) of interest. Within the context of a nested data structure, the intraclass correlation coefficient (ICC) can be examined to determine whether there is greater variability within individuals or between individuals for individual coping strategies used on a daily basis. Within the context of an EMA/DD study the ICC reflects the amount of between-individual variability for a target variable relative to total variability (the sum of between-individual and within-individual variability). The ICC is best estimated from a factor-analytic framework to reduce the amount of measurement error (or unique variance) in the calculation of this index (see B. O. Muthén, 1991; Zimprich & Martin, 2009). When measurement error is not accounted for the ICC is attenuated, suggesting less variability between individuals and more variability within individuals. Large ICC values reflect large differences in coping use between individuals but small differences in coping use within individuals; conversely, small ICC values reflect small differences in coping use between individuals but large differences in coping use within individuals. A large ICC is suggested to reflect rigidity in the use of coping (Lester, Smart, & Baum, 1994; C. E. Schwartz, Peng, Lester, Daltry, & Goldberger, 1998), whereas a small ICC might suggest coping strategies are more variable from assessment-to-assessment. In the few studies to model this type of variability with coping variables, De Ridder and Kerssens (2003) found significantly more variability across situations than between individuals (ICCs ranged from .08 to .30) and J. E. Schwartz et al. (1999) found more variation at the state than trait level using EMA/DD methodology for all coping items of interest. It is important to note, however, using variables from both levels of a nested data structure controls for the confound between within-person and between-person variation (see Heck & Thomas, 2009).

Coping dimensionality (structure) at both the state (within-person) and trait (between-person) levels can be evaluated using multilevel factor analysis (MFA;

Goldstein & Browne, 2005; Reise, Ventura, Nuechterlein, & Kim, 2005) in the context of an EMA/DD study (Stone et al., 2007). Individual coping strategies can be modeled at both the daily assessment level of use and at the individual person level of use. Covariation at the within-person level in MFA reflects each participant's use of specific coping strategies simultaneously more or less on any given day relative to their usual use. So, MFA allows one to determine if one's use of problem solving, for example, on a given day is associated with one's use of social support more on a given day. In contrast, variation at the between-person level in MFA reflects how participants rate themselves in coping usage relative to other participants (see Heck & Thomas, 2009; Hoffman, 2007; Reise et al., 2005). For example, one can determine if participants who are high on average use of problem solving (relative to other participants) are high on average use of social support (relative to other participants). Thus, when considering multiple coping strategies at the daily level one can model both the covariation of individual coping strategies over time and the average coping strategy use between individuals. Additionally important, however, is that this variation can be modeled to create latent variables at both levels of assessment that can be used for predictive purposes.

Traditionally, factor analyses have been conducted on data from cross-sectional designs using the individual as the unit of analysis (i.e., a single-level factor analysis). However, data from longitudinal designs has shown that characteristics of interest (e.g., coping, personality) may not be as stable as previously hypothesized (Hamaker, Nesselroade, & Molenaar, 2007). Using single timepoint measures (whether they are about a specific stressful event or a dispositional measure), then, inherently confound trait and state variation on the given occasion that the characteristic of interest is measured. Simply collecting longitudinal data where repeated observations are nested within individuals provides a method to tease apart state and trait variation for variables of interest and the factors that may underlie them. Beyond the confound between trait and state variance, single-level factor analysis has additional limitations when longitudinal data is available but not utilized optimally.

These limitations include treating the individual observations as independent and factor analyzing the total variance/covariance (or correlation) matrix (disaggregation approach); this approach would ignore between individual co(variation) across time. In contrast, summing or averaging variables across time (aggregation approach) and factor analyzing this variance/covariance matrix would ignore within-individual variability across time. Ignoring variability at both the within-person and between-person level of a nested data structure can result in biased parameter estimates (e.g., factor loadings; Kaplan, Kim, & Kim, 2009) and precludes the possibility that factor structures can differ at different levels of the hierarchical data structure (e.g., Kaplan et al., 2009; Kaplan & Kreisman, 2000; Zimprich & Martin, 2009).

MFA overcomes these limitations. MFA first involves establishing a nonzero ICC for each variable of interest (e.g., coping). This value would indicate that variability, and thus potentially covariation among coping variables, exists at both levels of the nested data structure. Once this is established, the total variance/covariance matrix is decomposed to reflect the two component parts: (a) within-person variance/covariance matrix (pooled across individuals) and (b) between-person variance/covariance matrix (relations among means of the target coping variables across time). These two sources of variability are best expressed by the multilevel linear factor model (for more statistical details see Goldstein & Browne, 2005; Kaplan et al., 2009; B. O. Muthén, 1989, 1991)

$$Y_{ti} = \nu + \Lambda_w \eta_{ti} + \varepsilon_{ti} + \Lambda_b \eta_i + \varepsilon_i,$$

where Y_{ti} is a vector containing the observed coping variables for each respondent (i) at each timepoint (t), ν is the grand mean, Λ_w is a factor-loading matrix for the within-individual coping variables, η_{ti} is a factor that varies randomly across time within-individuals, ε_{ti} are within-individual uniqueness terms, Λ_b is a factor-loading matrix for the between-individual coping variables, η_i is a factor that varies randomly across individuals, and ε_i are between-individual uniqueness terms. As can be seen from this equation, factor analysis is conducted on both components of the total variance/covariance matrix, thus allowing for the development of factor scores at each level of the nested data structure. Determination of the optimal number of factors at each level implements rules similar to those used for single-level exploratory factor analysis (e.g., descriptive indices of overall model fit, variance accounted for factors, interpretability of factor loadings; see MacCallum, 2009). These factor scores are interpreted similarly to factor scores derived from R-type factor analysis (Reise et al., 2005). It is important to note that development of factors at each level of the nested data structure removes measurement error from the target analyses.

CURRENT STUDY

This study serves as an introduction to the use of multilevel modeling in the context of an EMA/DD study to model *state* and *trait* components of coping variables. This application includes an assessment of the state and trait variance for coping variables and a series of MFAs of these coping variables to evaluate the factor structure for state and trait coping, respectively. Secondarily, this study also evaluates the predictive validity of derived factors at each level of the nested data structure on outcomes commonly used in EMA/DD studies (i.e., positive affect, negative affect; Zautra, Affleck, Tennen, Reich, & Davis, 2005) using multilevel structural equation modeling.

METHODS

Participants

Participants were college students recruited from a large western university. Three hundred sixty-six participants completed all target measures (to be described later). There were more female than male participants (68.5% vs. 31.5%) and their ages ranged from 17 to 25 years ($M = 20.14$, $SD = 2.10$). This multiethnic sample was composed of Caucasians (37.6%), Asian Americans (30.6%), Hispanics/Latinos (20.7%), African Americans (9.1%), and individuals who were either biracial or another ethnic group (2%). The sample also represented a cross section of majors at the university with larger percentages of Business (24.0%) and Psychology (15.9%) majors, respectively.

Daily Diary

Internet-based daily diaries were one page in length and assessed two primary constructs: coping and affect. Participants were first asked to describe the most stressful or bothersome event that had occurred to them in the current day using an open-ended format.

Coping was assessed with 14 specific coping strategies using a 4-point rating scale (1 = *not at all* to 4 = *a lot*). Participants were asked to report on the extent to which they used any of the specific strategies after the stressful event they had just described. These items were taken from Brief COPE (Carver, 1997), the Children's Coping Strategies Checklist and the How I Coped Under Pressure Scale (Ayers & Sandler, 2000), and the Responses to Stress Questionnaire (Connor-Smith, Compas, Wadsworth, Thomsen, & Saltzman, 2000). The strategies were selected to represent relatively distinct methods of coping. The 14 strategies included Cognitive Decision Making (e.g., *thought about what I need to know to solve the problem*), Direct Problem Solving (e.g., *did something to solve the problem*), Seeking Understanding (e.g., *thought about why it happened*), Positive Cognitive Restructuring (e.g., *tried to think about or notice only the good things in life*), Expressing Feelings (e.g., *cried to myself*), Humor (e.g., *laughed about the situation*), Religious Coping (e.g., *sought God's help*), Physical Release of Emotions (e.g., *went and exercised*), Distracting Actions (e.g., *watched TV and/or listened to music*), Avoidant Actions (e.g., *tried to stay away from things that made me upset*), Cognitive Avoidance (e.g., *tried to put it out of my mind*), Problem-Focused Support (e.g., *figured out what I could do by talking to my family*), Emotion-Focused Support (e.g., *talked to my friends about how I was feeling*), and Acceptance (e.g., *learned to live with it*). Each coping strategy was measured using two items as has been done in previous daily diary/experience sampling methodology studies (e.g., Hox & Kleiboer, 2007; Peters et al., 2000; Porter & Stone, 1996; Stone & Neale, 1984). Cronbach's

TABLE 1
Cronbach's Alpha, Means, Standard Deviations, and Intraclass Correlation Coefficients for the Coping Variables

Coping	*Cronbach's* α	M(SD)	*ICC*
Cognitive Decision Making	.70	2.78(0.95)	.35
Direct Problem Solving	.70	2.48(0.95)	.28
Seeking Understanding	.77	2.08(0.99)	.37
Positive Cognitive Restructuring	.62	2.00(0.90)	.45
Expressing Feelings	.48	1.78(0.80)	.29
Humor	.84	1.60(0.87)	.33
Religious Coping	.93	1.59(0.97)	.60
Distracting Actions	.47	1.84(0.84)	.38
Physical Release of Emotions	.73	1.50(0.82)	.46
Avoidant Actions	.60	1.84(0.86)	.29
Cognitive Avoidance	.45	2.32(0.90)	.35
Problem-Focused Support	.52	1.82(0.86)	.30
Emotion-Focused Support	.50	1.93(0.88)	.29
Acceptance	.76	2.08(0.99)	.40

Note. ICC = intraclass correlation coefficient.

alpha values are presented in Table 1 for each coping strategy.[1,2] The values presented in Table 1 are mean values aggregated across the five timepoints.

Daily affect was assessed with 20 adjectives from the Positive Affect Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). Items that comprised the positive affect (PA) scale and the negative affect (NA) scale, respectively, were rated using a scale that ranges from 1 (*very slightly*) to 5 (*very much*). Participants completed the PANAS according to *how they feel at this moment*. Both scale scores were highly reliable (mean αs = .93 and .90 for PA and NA, respectively).

Procedure

Participants were recruited via flyers, course/club presentations, and university seminars. Once individuals agreed to participate they received instructions (via

[1] It should be noted that calculation of Cronbach's alpha is tenuous with multilevel data (Hox & Kleiboer, 2007). However, alternative approaches for calculating multilevel reliability (e.g., Sampson & Raudenbush, 1999) require restrictive assumptions of equal item loadings and error variances or are difficult to estimate with two items per construct (Raykov & Marcoulides, 2006). In light of this, we chose to report Cronbach's alpha values.

[2] As shown in Table 1, the Cronbach's alpha values are low for some coping variables. Cronbach's alpha values will not necessarily be an accurate indicator of reliability with two-item coping variables (see Clark & Watson, 2003).

e-mail) on how to complete the Internet-based daily diary page over the course of five days. Participants were given a username and password (that they could change) to access the secured Web site in order to complete the diary page. These procedures are consistent with recent Internet-based daily diary studies (Armeli et al., 2005; Nezlek, 2005; Park, Armeli, & Tennen, 2004a, 2004b). Via this approach the date and time of each diary entry can be assessed; thus monitoring of compliance was increased. Participants received $25 for participating in the study.

RESULTS

Descriptive Statistics

There were a total of 1,782 observations (diary pages completed) for the 366 participants with an average of 4.87 observations per participant. Of the stressful events reported, 28.4% were related to academics (i.e., homework, tests) on average across days with smaller percentages of stressful events reported on social relationships with peers (20.7%) or family (17.5%), financial concerns (7.1%), and work-related concerns (6.8%). Means and standard deviations of the coping variables are presented in Table 1. Of the 14 observed coping variables only 3 had skewness values that exceeded 1 and 4 had kurtosis values that exceeded 1 (and all were less than 1.6).[3] The ICCs are also presented in Table 1 for the coping variables. The ICCs for all coping variables suggest a substantial amount of both within- and between-person variance. However, for 13 of the 14 coping strategies the ICC values are less than .50 with only Religious Coping exhibiting more between-person variation than within-person variation. In addition, Direct Problem Solving, Expressing Feelings, Avoidant Actions, and Emotion-Focused Support had the lowest ICC values. Thus, these coping strategies exhibit more within-person variation than other coping strategies.[4] Finally, the ICC values for positive and negative affect showed approximately

[3]Because the distributions of the observed coping variables were relatively normal and the sum of two items per coping variables, these variables were treated as continuous in the factor-analytic models. It should be noted, however, that these variables could also be treated as ordinal (see Goldstein & Browne, 2005).

[4]To account fully for measurement error in the calculation of the ICCs one must use item-level coping variables to create the 14 coping factors. The ICCs reported in Table 1 do not account for this measurement error. We did, in fact, evaluate item-level factor-analytic models for each of the 14 coping strategies. Due to the number of items per strategy (two) and the high correlations among the two items representing each coping strategy, these multilevel models did not converge, thus the ICCs were calculated from multilevel models where the dependent variables were an aggregate of the two items that reflected each of the 14 coping strategies.

equal amounts of within- and between-person variance (ICCs = .42 and .44, respectively).

Multilevel Factor Analysis (MFA)

A series of MFAs was conducted to determine the factor structure for the coping data at both the within-person level and the between-person levels. A maximum likelihood estimation procedure that is robust to nonnormality of data and nonindependence of observations was used in Mplus 5.1 (L. Muthén & Muthén, 2006). Geomin rotation was used for all models. These models varied in the number of factors specified at each level of the nested data structure (from 1 to 4 factors).[5] In order to determine the best-fitting model (a) the root mean square error of approximation (RMSEA; Steiger, 1990), a descriptive index of overall model fit with values less than .08 indicative of a plausible model and values less than .05 indicative of well-fitting models, and (b) the standardized root mean square residual (SRMR), a descriptive index of overall model fit with values less than .08 indicative of a plausible model and values less than .05 indicative of a well-fitting model, were used. The use of these two descriptive fit indices is consistent with recent measurement research (see Millsap & Kwok, 2004). The likelihood ratio χ^2 and associated degrees of freedom are also reported. In addition, the variance accounted for by each factor, the variance accounted for the solution, and the interpretability of the pattern matrix were all considered in making a determination of the best-fitting model.

As shown in Table 2, models including a minimum of three factors at both the within- and between-levels, respectively, fit reasonably well according to both descriptive fit indices. In particular the models that specified (a) three Within-4 Between factors and (b) 4 Within-4 Between factors fit best according to the more stringent cutoff values for the RMSEA and SRMR. Using χ^2 difference testing of the log-likelihood values for these two models,[6] the 4 Within-4 Between factor model fit significantly better, $\Delta\chi^2(df = 11) = 110.30$, $p < .001$. The eigenvalues (and variances accounted for by each factor) were: (a) Within: 3.38 (24.1%), 1.68 (12.0%), 1.28 (9.1%), 1.08 (7.7%); (b) Between: 6.76 (48.3%), 1.44 (10.3%), 1.22 (8.7%), 1.07 (7.6%). The variance accounted for by the solution was 52.9% at the within-person level and 74.9% at the between-person level.

The pattern matrix coefficients for this model are presented in Table 3. Based on the suggestions of Comrey and Lee (1992), items with primary pattern matrix

[5] Specification of five factors at both or either level of the data structure resulted in models that could not be estimated (i.e., model estimation did not converge).

[6] For information on how to conduct these model comparisons see the Mplus Web site (http://www.statmodel.com/chidiff.shtml).

TABLE 2
Overall Model Fit for Exploratory Multilevel Factor Analysis

Model (Factors)	χ^2 (df)	*RMSEA*	*SRMR(Within/Between)*
1 Within-1 Between	2,142.7(154)	.085	.100/.123
2 Within-1 Between	1,349.7(141)	.069	.067/.134
3 Within-1 Between	853.1(129)	.056	.045/.137
4 Within-1 Between	766.4(118)	.056	.035/.140
1 Within-2 Between	2,316.0(141)	.091	.093/.096
2 Within-2 Between	1,203.0(128)	.069	.066/.113
3 Within-2 Between	751.6(116)	.055	.045/.121
4 Within-2 Between	659.0(105)	.054	.036/.118
1 Within-3 Between	1,722.4(129)	.083	.093/.068
2 Within-3 Between	1,090.7(116)	.069	.065/.069
3 Within-3 Between	611.2(104)	.052	.043/.068
4 Within-3 Between	504.7(93)	.050	.033/.065
1 Within-4 Between	1,560.6(118)	.083	.093/.050
2 Within-4 Between	936.5(105)	.067	.063/.045
3 Within-4 Between	541.1(93)	.052	.042/.037
4 Within-4 Between[a]	392.7(82)	.046	.031/.039

Note. RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual.

[a]The 4 Within-4 Between factor model was deemed the best-fitting model.

coefficients (loadings) greater than .45 with secondary pattern matrix coefficients less than .25 were identified as *practically significant*. At the within-level of the target MFA, Acceptance, Avoidant Actions, Positive Cognitive Restructuring, and Distracting Actions all loaded on the first factor; this factor is referred to as Minimization of stressor coping dimension. Cognitive Decision Making and Direct Problem Solving loaded on the second factor; this factor is referred to as the Problem-Focused coping dimension. Emotion-Focused Support and Problem-Focused Support loaded on the third factor; this factor is referred to as the Social Support dimension. Seeking Understanding and Expressing Feelings loaded on the fourth factor; this factor is referred to as an Emotional Rumination dimension. Cognitive Avoidance, Physical Release of Emotions, Humor, and Religious Coping did not load on any one factor at the within-person level. Interfactor correlations are presented at the top of Table 4 among the four factors. Statistically significant and positive correlations were found between (a) the Minimization factor and both the Social Support and Emotional Rumination factors, (b) Problem-Focused coping and Social Support, and (c) Social Support and Emotional Rumination.

At the between-person level of the target MFA, Avoidant Actions and Cognitive Avoidance loaded on Factor 1; this factor is referred to as an Avoidance cop-

TABLE 3
Pattern Matrix Coefficients (and Standard Errors) for the
4-Within and 4-Between Factor Model

	Factor			
Coping Strategy	*1*	*2*	*3*	*4*
Within variables				
Acceptance	**.45**(.12)	−.03(.05)	−.04(.04)	−.06(.16)
Avoidant Actions	**.52**(.08)	−.09(.05)	−.04(.04)	.17(.12)
Positive Cognitive Restructuring	**.45**(.09)	.06(.05)	.07(.04)	.13(.12)
Distracting Actions	**.47**(.11)	.12(.05)	.03(.05)	−.04(.06)
Cognitive Decision Making	.02(.03)	**.62**(.03)	.03(.02)	.02(.05)
Direct Problem Solving	−.02(.04)	**.77**(.04)	−.06(.02)	.00(.02)
Emotion-Focused Support	.00(.02)	−.06(.06)	**.99**(.02)	−.02(.02)
Problem-Focused Support	.02(.03)	.11(.04)	**.70**(.06)	.05(.04)
Seeking Understanding	.02(.09)	.07(.05)	.03(.04)	**.65**(.10)
Expressing Feelings	−.02(.07)	.00(.03)	.20(.06)	**.47**(.13)
Cognitive Avoidance	.43(.10)	−.19(.05)	−.02(.02)	.36(.12)
Physical Release of Emotions	.37(.12)	.17(.05)	.11(.05)	−.12(.12)
Humor	.20(.07)	.01(.04)	.14(.04)	.04(.08)
Religious Coping	.18(.07)	.09(.04)	.12(.05)	.20(.08)
Between variables				
Avoidant Actions	**.70**(.11)	.02(.07)	.02(.06)	.23(.14)
Cognitive Avoidance	**.99**(.09)	.01(.07)	−.02(.06)	.14(.20)
Cognitive Decision Making	.17(.18)	**.86**(.15)	.04(.04)	−.24(.08)
Direct Problem Solving	−.05(.14)	**.92**(.09)	.02(.07)	.01(.04)
Emotion-Focused Support	−.03(.04)	.02(.09)	**.99**(.10)	−.06(.05)
Problem-Focused Support	.01(.03)	.12(.08)	**.84**(.11)	.09(.07)
Distracting Actions	.17(.13)	.03(.08)	.07(.15)	**.64**(.13)
Physical Release of Emotions	.04(.10)	−.02(.06)	.24(.07)	**.61**(.12)
Expressing Feelings	.39(.10)	−.03(.10)	.53(.12)	.00(.05)
Humor	−.04(.05)	.50(.14)	−.05(.06)	.53(.10)
Seeking Understanding	.40(.11)	.42(.15)	−.02(.12)	.07(.09)
Religious Coping	.22(.11)	−.16(.13)	.23(.21)	.21(.12)
Positive Cognitive Restructuring	.42(.10)	.34(.12)	.00(.08)	.29(.11)
Acceptance	.36(.11)	.38(.17)	.07(.11)	.05(.13)

Note. Values in bold indicate primary pattern matrix coefficients > .45 that also had secondary pattern matrix coefficients < .25.

ing dimension. Cognitive Decision Making and Direct Problem Solving loaded on Factor 2; this factor is referred to as the Problem-Focused coping dimension. Emotion-Focused Support and Problem-Focused Support loaded on Factor 3; this factor is referred to as the Social Support dimension. Distracting Actions and Physical Release of Emotions loaded on Factor 4; this factor is referred to as a Distraction dimension. Acceptance, Positive Cognitive Restructuring,

TABLE 4
Interfactor Correlations at Both the Within and Between Levels

Coping Factor	*(2)*	*(3)*	*(4)*
Within-Level			
(1) Minimization	.03	.34*	.34*
(2) Problem-Focused		.23*	.07
(3) Social Support			.33*
(4) Emotional Rumination			
Between-Level			
(1) Avoidance	.45*	.41*	.33*
(2) Problem-Focused		.58*	.25*
(3) Social Support			.36*
(4) Distraction			

*$p < .05$.

Expressing Feelings, Seeking Understanding, Humor, and Religious Coping did not load on any one factor. Interfactor correlations are presented at the bottom of Table 4. Statistically significant and positive correlations were found between (a) the Minimization factor and both the Problem-Focused coping and Social Support factors and (b) Problem-Focused coping and Social Support. However, the interfactor correlations among the trait factors are generally larger than those found among the state factors.

ICCs were also calculated for each factor that was derived regardless of level for the nested data structure. The ICCs, in general, suggested an equal amount of variability at the state and trait level for Avoidance coping (.53), Problem-Focused coping (.51), Distraction (.53), and Emotional Rumination (.56). Larger ICC values, indicative of more trait variance than state variance, were evident for Minimization (.75) and Social Support (.65).

Multilevel Structural Equation Modeling Predicting Daily Affect With Coping Factors

To test the predictive validity of the coping factors at both levels of the nested data structure, a structural equation model for the multilevel data was used to predict NA and PA, respectively. Latent variables were specified for all four coping factors at each level. This model fit reasonably well, $\chi^2(df = 904) = 5041.8$, RMSEA = .05, SRMR(Within/Between) = .07/.07. Coping factors accounted for a significant amount of variance for both NA and PA at both the within-person ($R^2_{NA} = .19$; $R^2_{PA} = .10$) and between-person levels ($R^2_{NA} = .16$; $R^2_{PA} = .37$). As shown in Table 5, at the within-person level only the Emotional Rumination

TABLE 5
Unstandardized Regression Coefficients (Standard Errors) Predicting NA and PA With Coping Factors Strategies

	NA		*PA*	
Coping	b_{Within}	$b_{Between}$	b_{Within}	$b_{Between}$
Within predictor variables				
Minimization	−.19(.12)		**.40**(.12)	
Problem-Focused Coping	−.06(.08)		**.26**(.10)	
Social Support	−.05(.05)		.03(.05)	
Emotional Rumination	**.61**(.12)		**−.22**(.08)	
Between predictor variables				
Avoidance		**.57**(.18)		−.16(.20)
Problem-Focused Coping		.00(.12)		**.64**(.14)
Social Support		−.03(.17)		−.09(.19)
Distraction		−.04(.20)		**.68**(.22)

Note. NA = negative affect; PA = positive affect.
Values in bold were statistically significant, $p < .05$.

factor was statistically significant and positively associated with NA; at the between-person level only the Avoidance factor was statistically significant and positively associated with NA. In predicting PA at the within-person level, the Minimization of Stressor and Problem-Focused coping factors were statistically significant and positively associated with PA, whereas the Emotional Rumination factor was statistically significant and negatively associated with PA. At the between-person level Problem-Focused coping factor was statistically significant and positively associated with PA, whereas the Emotional Rumination factor was statistically significant and negatively associated with PA.

DISCUSSION

The results of this study show how innovative data collection and statistical methodologies can be implemented to provide a different perspective on how the stress and coping process can be evaluated. Specifically, the results of this study suggest that (a) different factor structures can emerge when evaluating state and trait variation of coping variables, (b) the covariation among these factors is generally smaller among state (vs. trait) factors, and (c) these factors differentially predict target outcomes; in the multilevel structural equation modeling models, more state-level factors were predictive of the target outcomes. Measures that assess dispositional coping or retrospective recall of a stressor at a single timepoint would not be able to explore these two meaningful sources

of (co)variation. Thus, EMA/DD and multilevel factor-analytic methods provide a different perspective of the stress and coping process, namely, the addition of a within-person component.

The primary purpose of this study was to estimate within-person (state) and between-person (trait) components of coping variables within the nested data structure that an EMA/DD study provides and then use factors/variables derived from each level of the data structure for predictive purposes. The amount of variance identified at each level of the nested data structure provides an indication of whether or not coping strategies are being used rigidly across time or varying relative to an individual's own use of a coping strategy. The ICCs for all of the coping factors exceeded were approximately .50 with the exception of the Minimization of stressor and Social Support factors, respectively, showing similar levels of between-person variability and within-person variability. Thus, it seems plausible to suggest that some individuals bring a dispositional quality (i.e., consistency of responding) to these person-environment interactions captured by EMA/DD methodology. These findings are consistent with person-environment models of coping (e.g., Dohrenwend & Dohrenwend, 1978; Wortman, Sheedy, Gluhoski, & Kessler, 1992), which emphasize the relative (im)balance between the demands of the situation and the stable resources of the individual. This finding is consistent with a recent daily diary study (Todd, Tennen, Carney, Armeli, & Affleck, 2004) that found Religion to be more traitlike, and coping strategies such as Planning, Active Coping, and Venting Emotions were not (between-person variance 17–30% with between-person variance even lower for Positive Reinterpretation and Acceptance [< 14%]).

Identifying these two types of variation within the context of an EMA/DD study is important for additional reasons. First, operationally, coping is traditionally measured by using one of two instruction sets that prompt participants to rate coping items with respect to how one copes in general or how one has coped with a specific stressor over a predefined period of time (e.g., over the last week). Neither approach measures state coping with the rigor that an EMA/DD study provides (see Shiffman et al., 2008). In addition, single timepoint measures confound the possibility that traitlike and statelike variables are possible (Cole & Maxwell, 2009). Using multilevel modeling with EMA/DD data allow researchers to capture moment-to-moment coping activities and model this within-person (co)variability while at the same time estimating reliable between-person variability. The aggregation of within-person assessments across time reduces the noise inherent in single timepoint measures error relative to single assessments and provides a more statistically reliable and powerful measure of the construct(s) of interest (Shiffman, 2007). However, it should be emphasized that EMA/DD studies do not completely eliminate self-report bias.

Using EMA/DD designs for the measurement of constructs at the trait and state level are vital to the behavioral and social sciences. Application of these

techniques has been successfully implemented using diathesis-stress (e.g., Myin-Germeys, van Os, Schwartz, Stone, & Delespaul, 2001) and personality-coping diathesis (e.g., Roesch, Aldridge, Vickers, & Helvig, 2009) models. Moreover, it has been shown that core constructs in psychology, for example, depressed affect, are quite variable (see Barge-Schaapveld, Nicolson, Berkhof, & deVries, 1999; Williams et al., 2004), and the correlations between EMA/DD assessments of depression and anxiety and global recollection measures are minimal (25% shared variance at the most; see Turk, Burwinkle, & Showlund, 2007). Daily hassles/minor stressful events have a cumulative effect on psychological and physical health (Almeida, 2005) and can result in serious stress and anxiety (Zautra, 2003). These effects have also been shown in EMA/DD studies linking state variation in stress/mood to target outcomes such as anxiety disorders, smoking, alcohol use/abuse, and physical health (see Piasecki, Hufford, Solhan, & Trull, 2007; Stone et al., 2007; Tennen, Affleck, Coyne, Larsen, & DeLongis, 2006; Thiele, Laireiter, & Baumann, 2002, for reviews). This is not to suggest that traits do not impact outcomes of interest but rather to highlight that current measurement practices are limited with regard to modeling state variation.

Furthermore, it could be argued that the global recollection in reporting disposition coping versus day-to-day coping is reflective of different processes and represents different types of coping. Stone et al. (1998) have suggested that the two methods of assessment may capture different information with the global recollection method emphasizing broader coping dimensions (in other words, what someone does in general when encountering stress), whereas EMA/DD captures more fine-grained moment-to-moment coping activities (employment of specific coping strategies). Dispositional coping implicitly asks respondents to summarize their behavior/cognitions across situations. Not surprisingly, this method produces lower intensity or frequency values for coping measures (Carney, Tennen, Affleck, del Boca, & Kranzler, 1998; Litt, Cooney, & Morse, 2000; Shiffman, 2007; Shiffman, Ferguson, Gwaltney, Balabanis, & Shadel, 2006). Moreover, aggregating repeated assessments in an EMA/DD study obviates the measurement error of single assessment, global recollection measures, thus improving the reliability of measures and increasing statistical power (Shiffman, 2007). With respect to contextual information, daily process variables representing stress can be studied at the within-person level using EMA/DD. These characteristics include elements of the stressor (e.g., frequency, perceived stressfulness, type of stress) and subjective appraisal (e.g., severity of loss, threat, challenge). Global recollection measures would likely miss this important information. In fact, some (e.g., Carver & Connor-Smith, 2010) have suggested that researchers abandon cross-sectional retrospective research decisions because contextual information is lacking. It is important to note, however, as summarized by Shiffman et al. (2008), momentary assessments and global recollections may be appropriate for different questions. If one is interested in how an

individual coped with a specific stressor in the moment, EMA/DD is likely the more valid approach. If one is more interested in a global understanding or perceptions of the target event, global recollective methods may be more valid.

Clearly, MFA can be used to evaluate the factor structure of coping (or other relevant variables) collected from EMA/DD studies. Only one previous study (Park et al., 2004a) has attempted factor analysis using daily diary data or model the relations between coping and outcomes in the context of this type of design. These researchers, however, conducted factor analyses on daily diary data at three discrete timepoints during the study and thus did not take full advantage of modeling within- and between-person variation. Covariation among coping variables at the within- and between-person levels of the nested data structure further informs the trait-state distinction. At the within-person level, factors derived indicate individual coping strategies that co-occur (are correlated enough) at each individual assessment period. For example, the individual coping strategies Cognitive Decision Making and Direct Problem Solving were used consistently and simultaneously enough at the daily level to compose a State Problem-Focused coping factor. At the between-person level, coping use is aggregated across assessment period (i.e., the 5 days of assessment) at the individual coping strategy level. Thus, factors derived indicate individual coping strategies that co-occur at the *mean level* of use (to reflect trait coping use).

Although it is beyond the scope of this article to address the interpretability of the factor structure found at the within- and between-person levels with respect to previous factor analytic research in this area (see Skinner et al., 2003, for a review), we briefly summarize the factor structure with respect to the (in)consistency found between the two levels of the nested data structure. In general, the MFAs revealed that the factor structure was largely similar at both the within-person and between-person levels. Both Problem-Focused coping and Social Support factors, respectively, emerged from the data. This suggests that these two factors are robust when state and trait covariation are modeled. These factors found in these analyses are generally interpretable in light of global dimensions commonly found on coping instruments (e.g., Coping Strategies Indicator; Amirkhan, 1990; Ways of Coping; Lazarus & Folkman, 1984). Interestingly, however, the first factor identified at the state and trait levels, respectively, were different. Certainly one could argue that the state Minimization of stressor factor and the trait Avoidance factor are conceptually similar in that there is some overlap in strategy composition—both contain Avoidant Actions as an indicator. The Minimization factor and the Avoidance coping factor are both conceptually similar to what Skinner et al. (2003) identified as Avoidance. However, the Minimization factor differs in an important way from a more *traditional* Avoidance dimension; the Minimization factor is a blend of some avoidance coping with Positive Cognitive Restructuring (at the within-person level). This suggests the state Minimization factor has a conceptual meaning different from

trait Avoidance. The emergence of the Minimization factor suggests that at the daily, within-person level participants use these strategies in a consistent manner. Rather than Avoidance, this state factor could be conceptualized as Accommodative coping or Secondary Control with an emphasis on attention redeployment and maximizing one's fit to the current conditions (Skinner & Wellborn, 1994). This perspective is consistent with accommodation or secondary control, which subsumes acceptance, and positive cognitive restructuring (Skinner & Wellborn, 1994; Walker, Smith, Garber, & Van Slyke, 1997). It is important to note that these two factors differentially predicted target outcomes. The state Minimization factor was significantly and positively associated with positive affect, whereas the trait Avoidance factor was significantly and positive associated with negative affect. These sources of variation would have been confounded in a traditional single timepoint assessment. The fact that they are differentially related to outcomes suggests both sources of variation are important.

Similarly, the fourth factors identified at the state and trait levels, respectively, were different. At the within-person level an Emotional Rumination factor emerged, whereas at the between-person level a Distraction factor emerged. The state Emotional Rumination factor was a blend of Expressing Feelings and Seeking Understanding. This conceptual meaning of this factor is consistent with Skinner et al.'s (2003) conceptualization, which includes intrusive thoughts, negative thinking, and anxiety amplification. Use of Seeking Understanding in isolation can be an adaptive coping strategy as it is generally defined as making meaning out of a stressful event. When covarying with Expressing Feelings, however, this factor appears to represent fearful, self-blame coping responses. Consistent with this line of thinking, this factor was significantly and positively associated with negative affect and significantly and negatively associated with positive affect at the state level. Conversely, at the between-person level a Distraction factor composed of Distracting Actions and Physical Release of Emotions emerged. This factor is identical to that identified by Ayers, Sandler, West, & Roosa (1996). Kuo, Roysircar, and Newby-Clark (2006) identified a similar factor that they identified as Relaxation. This factor can be viewed as a trait emotional regulation factor, where individuals who engage in these coping strategies are constructively expressing emotion at the right time and place. That is, these strategies appear to provide individuals with a "rest" from dealing with the stressor. The fact that the Distraction factor was significantly and positively associated with PA suggests that these strategies are adaptive.

Finally, the predictive validity of derived factors at each level of the nested data structure on outcomes commonly used in EMA/DD studies can be evaluated. Studies have not compared potential differences at the state and trait levels; we now do so descriptively. When considering the prediction of negative affect at the state level, only the Emotional Rumination factor was a statistically significant (positive) predictor. At the trait level, only the Avoidance coping fac-

tor was statistically significantly associated with negative affect. These findings are novel in that different types of "Avoidance" were predictive depending on the variability of interest. Similarly in the prediction of positive affect, three of the four coping factors (Minimization, Problem-Focused Coping, Emotional Rumination) were statistically significantly associated with PA at the state level. At the trait level, two of the four coping factors (Problem-Focused Coping, Distraction) were statistically significantly associated with PA. It is important that the findings from the MSEM analyses highlight the importance of modeling the two sources of variability of interest in this study for predictive purposes. Across the two outcomes, only Problem-Focused Coping was a consistent predictor (of PA) when evaluated at the state and trait levels. The majority of the associations between a target factor and outcome were dependent upon the level at which the factor was assessed.

Many methodological and substantive limitations can be noted in this study that prohibit firm conclusions from being drawn not only for the assessment and quantification of state and trait variability, but also the relationships between these sources of coping variability and the target outcomes. First, the number of assessment periods and use of end-of-the-day reports are questionable. With respect to the end-of-the-day reports, some research has found that this assessment method is susceptible to recency and saliency heuristic biases (e.g., Hedges, Jandorf, & Stone, 1985; see Stone et al., 2007). Certainly, using multiple assessments over more days would enhance the quantification of state and trait variability but minimize further these biases. Second, the measures used are self-report, and thus the data do not overcome this potential source of bias. However, as noted by Stone (2007) and Chan (2009), self-reports are necessary to assess self-referential perceptions (e.g., how one has coped or is currently feeling) but clearly could be supplemented with other measures (e.g., peer reports). Third, measurement error could not be removed from the individual coping strategies in the calculation of the ICCs, thus overestimating state variability to a degree at the individual strategy level. Because of this limited number of items per coping strategy, estimation of coping factors from item-level data was not possible. Fourth, researchers could disagree with the composition and labeling of the factors. There has been a general lack of consensus in coping categories/dimensions as noted by Skinner et al. (2003). Related to this, the factor structure of coping measures is typically unstable (Perrez, 2001; Schwarzer & Schwarzer, 1996), thus the factor structure derived here, arguably, might not generalize to other populations, methodological designs, and coping measures.

In summary, this study was successful at showing that state and trait variation could be modeled within the context of an EMA/DD study. Intraclass correlation coefficients for the derived factors suggested approximately equal amounts of state and trait level variation. MFAs showed that Problem-Focused Coping and Social Support emerged as stable factors at both the within-person and

between-person levels of the nested data structure. Other factors (Minimization, Emotional Rumination, Avoidance, Distraction) were specific to the within-person or between-person levels but not both. These factors, and the levels that they were derived from, were differentially predictive of negative and positive affect, relationships that could not be found using a single timepoint assessment.

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