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Combinations of Stressors in Midlife: Examining Role and Domain Stressors Using Regression Trees and Random Forests

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Objectives. Global perceptions of stress (GPS) have major implications for mental and physical health, and stress in midlife may influence adaptation in later life. Thus, it is important to determine the unique and interactive effects of diverse influences of role stress (at work or in personal relationships), loneliness, life events, time pressure, caregiving, finances, discrimination, and neighborhood circumstances on these GPS.

Method. Exploratory regression trees and random forests were used to examine complex interactions among myriad events and chronic stressors in middle-aged participants' (N = 410; mean age = 52.12) GPS.

Results. Different role and domain stressors were influential at high and low levels of loneliness. Varied combinations of these stressors resulting in similar levels of perceived stress are also outlined as examples of equifinality. Loneliness emerged as an important predictor across trees.

Discussion. Exploring multiple stressors simultaneously provides insights into the diversity of stressor combinations across individuals—even those with similar levels of global perceived stress—and answers theoretical mandates to better understand the influence of stress by sampling from many domain and role stressors. Further, the unique influences of each predictor relative to the others inform theory and applied work. Finally, examples of equifinality and multifinality call for targeted interventions.

Key Words: Loneliness—Random forests—Regression trees—Stress.

MIDDLE age is a period of marked diversity (Lachman, 2004). During midlife, individuals juggle many competing demands, including roles as workers, spouses, parents, and adult children. They may experience precursors to health problems (e.g., high cholesterol) or some of the same conditions as their parents (e.g., diabetes). A range of expected (e.g., retirement, children leaving home) and unexpected (e.g., loss of spouse, being laid off) events may occur during midlife. Aldwin and Levenson (2001) propose that stress and coping processes in midlife contribute to the individual differences in chronic health problems found in middle age and later life. Stressful experiences in adulthood may provide a context for development (Aldwin, 1994), with challenging experiences in midlife serving as opportunities to adapt and hone emotion regulation skills for later life periods (Magai & Halpern, 2001).

In the short term, however, the "fullness" of everyday life during middle age, with its diverse roles, responsibilities, and demands, may contribute to global perceptions of stress (GPS). GPS reports reflect individuals' feelings of overload, uncontrollability, unpredictability, and distress about life. As measured by the *Perceived Stress Scale* (PSS), this instrument uses a 30-day recall period and is designed to detect current levels of strain from ongoing chronic stressors, impending events, and past events (Cohen, Kamarck, & Mermelstein, 1983). GPS predicts a number of physical and mental health outcomes including depressive symptoms (Cohen et al., 1983), susceptibility to colds (Cohen, Tyrrell, & Smith, 1993), changes in smoking rate (Cohen et al., 1983), decreased gray matter volume in the hippocampus (Gianaros et al., 2007), and telomere length and oxidative stress as biological correlates of longevity (Epel et al., 2004). Further, individuals who report high levels of GPS are more affected by the experience of daily events (Stawski, Sliwinski, Almeida, & Smyth, 2008; van Eck, Nicolson, & Berkhof, 1998). These ratings also change within persons across time; in longitudinal studies, individuals are more responsive to daily events during periods when they report higher levels of GPS than during periods when they report lower GPS (Sliwinski, Almeida, Smyth, & Stawski, 2009). Despite the theoretical assumption that GPS serves to aggregate life stress from multiple sources and evidence for it as a predictor of a range of outcomes, little is known about the situations that actually contribute to appraising life this way.

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The goal of this study is to identify combinations of chronic stressors and life events that middle-aged persons face and to explore how these relate to their overall perceptions of current life stress. We have particular interest in systems theory's (Von Bertalanffy, 1969) concepts of *multifinality* (i.e., shared stressor profiles resulting in different levels of GPS) and *equifinality* (i.e., different combinations of stressors related to similar levels of GPS). Evidence for multifinality and equifinality has implications for both stress theory and intervention.

Examining Multiple Stressors Together

Wheaton (1994) has described continua (Wheaton & Montazer, 2010) over which components of the "stress universe" can vary: discreteness (e.g., acute life events and chronic stressors), macrolevel to microlevel, life course (e.g., time at which stressor occurs relative to developmental period), and severity. This orientation, as well as others'—including notions of stress proliferation (Pearlin, Schieman, Fazio, & Meersman, 2005) and life course perspective (Aneshensel, 1992; Elder, George, & Shanahan, 1996; Pearlin et al., 2005)—emphasizes that stress experiences are contemporaneously and temporally contextualized. An implication of this is that acute and chronic stressors are experienced in concert with one another rather than individually (Pearlin & Skaff, 1996; Wheaton, 1997); therefore, it is unlikely that any one stressful experience is the sole determinant of well-being. Indeed, Pearlin (1989, p. 241) encouraged examining the "*constellations* of stressors made up of both events and strains." Researchers have responded, documenting that middle-aged women balancing care for relatives with AIDS with their other role commitments (Wight, LeBlanc, & Aneshensel, 1998), bidirectional effects between stress in work and family roles (Eckenrode & Gore, 1990), and the impact of individual traumas is attenuated by prior stress histories (Wheaton, Roszell, & Hall, 1997).

According to the *stress domain hypothesis* (Wheaton, 1999), modest results found in past studies linking life events to mental and physical health may be due to their assessing a single source of stress that does not embody the full effect of a stressor embedded in a social context. When a variety of stress types (e.g., traumas, life events, chronic stressors, and daily hassles) have been examined simultaneously, both unique and indirect effects on distress were found (Wheaton & Montazer, 2010). Stress studies have primarily been main effect focused (Wheaton & Montazer, 2010) or, in the case of the notable studies mentioned earlier, limited in the number of predictors and interactions. This was due, in part, to power constraints and analytic techniques that limit the number of interactions that can be examined. In this study, we employ regression trees (RT) and random forests (RF) to build on the rich theory on the various and mutually influencing stressors to document how these diverse stressors relate to one other and influence perceptions of stress. Subsequently, we overview chronic stressors and life events from many domains particularly relevant to midlife; then, we introduce an analytic approach, relatively novel to stress research, to examine how complex interactions between events and chronic stressors across domains may be related to individuals' subjective perceptions of life stress.

Chronic Stressors

Chronic stressors include enduring problems, conflicts, and threats that people face in their everyday lives (Cohen, Kessler, & Gordon, 1997; Turner, Wheaton, & Lloyd, 1995); these stressors persist over time (Pearlin & Skaff, 1996) and have been described as a continuous reality or state (Wheaton, 1999). *Role strains* include ongoing problems that arise from social roles, particularly family relationships, whereas *ambient strains* pertain to problematic facets of person–environment interactions (Pearlin & Skaff, 1996). Highlighting the overlapping nature of stressful experiences (Lepore, 1997), acute life events may be particularly stressful when they lead to more chronic role strains (Krause, 1994), such as job loss (Elder & Liker, 1982), divorce (Pearlin & Johnson, 1977), and widowhood (Pearlin & Lieberman, 1979).

Role stressors.—Family, caregiving, romantic relationships, and work. The consequences of recurring stressors may be particularly severe when they surface within major social domains, such as work or family (Pearlin, 1989; Wheaton, 1994). Emergent role strains, such as caregiving, peak in midlife—one in five provides some degree of caregiving (Brody, 1985; Marks, 1998)—and can be a source of enduring stress. Moreover, events like children's departure, parents' death, and retirement may exacerbate strains produced by the multiple roles held during midlife (Wethington, Kessler, & Pixley, 2004; Willis & Reid, 1999). Although some role combinations can lead to beneficial effects on well-being (Moen, Dempster-McClain, & Williams, 1989, 1992; Thoits, 1983; Vandewater, Ostrove, & Stewart, 1997), occupying multiple roles may introduce conflicting expectations leading to overload or conflict (Coverman, 1989). Because caregiving is often done in combination with the potentially conflicting demands of paid employment (Marks, 1998), women in the workplace may find it difficult to satisfy their work requirements along with the demands of caregiving for children and frail parents (Aneshensel et al., 1995; Pearlin & Johnson, 1997). Apart from its conflict with other roles, work itself is a significant source of stress in midlife, as adults in this period are still likely to be involved in full-time employment, with many having reached positions involving considerable management responsibilities and time demands. Chronic stressors related to one's job or career negatively affect both short-term health indicators and long-term

health outcomes, including heightened cortisol responses (Schlotz, Hellhammer, Schulz, & Stone, 2004) and greater allostatic load (Bellingrath, Weigl, & Kudielka, 2009).

Ambient stressors across life domains.—Loneliness, finances, health, and neighborhood. Although statistics vary, research has indicted that 20%–40% of adults report feeling lonely at any given point in time and 5%–10% report persistent loneliness (Luo, Hawkley, Waite, & Cacioppo, 2012). Model of loneliness of Cacioppo, Hughes, Waite, Hawkley, and Thisted (2006) and Hawkley and Cacioppo (2010) describes a downward social spiral that often occurs for lonely individuals. *Loneliness* has been defined as (a) the difference between desired and actual social relationships (Luo et al., 2012) and (b) the stress that accompanies having few (or no) social relationships or perceiving a lack of meaningful and fulfilling connections with others (Lepore, 1997). Loneliness relates to morbidity and mortality (even after controlling for age, socioeconomic status [SES], race, blood pressure, body mass index, physical disability, tobacco use, and cholesterol levels; Cacioppo et al., 2006; Hawkley, Burleson, Berntson, & Cacioppo, 2003; Hawkley & Cacioppo, 2010; Hawkley, Thisted, Masi, & Cacioppo, 2010; Seeman et al., 1993), poor immune function (Kiecolt-Glaser & Glaser, 1991), and depression (Rook, 1984). *Social Production Function Theory* (Ormel, Lindenberg, Steverink, & Verbrugge, 1999; Steverink, Veenstra, Oldehinkel, Gans, & Rosmalen, 2011) suggests that loneliness produces a deprivation of basic human needs and, as such, works as a stressor. Thus, human interconnection is a basic condition for functioning and if this is lacking, health problems result (Deci & Ryan, 2000). Based on this literature and a similar analysis in older adults (Scott, Jackson, & Bergeman, 2011), loneliness may be a particularly influential ambient stressor that affects the way people perceive the other domains of their lives as well as how stressful their lives are overall.

Chronic stressors in the domains of finance, health, and neighborhood are other examples of ambient stressors. Because middle-aged adults tend to be professionally accomplished and financially stable, financial stress is likely to stem from the many large-scale fiscal responsibilities present at this point in the life span (e.g., mortgages, college tuition, retirement savings, and medical care; Antonucci, Akiyama, & Merline, 2001; Easterlin, 2006). Economic events, such as the recent recession, can transform these financial concerns to feelings of stress (Meltzer et al., 2010). Chronic health conditions in midlife are not as normative as they become in later life; a given middle-aged individual may be the only one in his/her social network who is experiencing a certain functional limitation, and this is likely to have a substantial contribution to his/her experience of stress. Indeed, research demonstrates that midlife adults diagnosed with fibromyalgia report higher levels of perceived stress when their symptoms are more severe and cause a greater degree of disability (Murray, Daniels, & Murray, 2006). Finally, the condition of an individual's neighborhood is a substantial factor contributing to a sense of overall security, with levels of neighborhood-related stress largely dependent on the availability of supportive neighbors and community resources (Pearlin & Skaff, 1996; Yen, Michael, & Perdue, 2009). For adults in midlife, the concern with safety of children who still live at home may make neighborhood strain an even more salient contributor to perceived stress.

Life Events and Discrimination

Life events, in contrast to chronic stressors, are discrete and observable events with concrete beginnings and endings (Wheaton, 1999). They may be tied to the life cycle and associated transitions (e.g., marriage, retirement, and widowhood; Holmes & Rahe, 1967). Although no general consensus exists on the age of entry to and exit from midlife (Lachman & James, 1997), there is some agreement concerning the various normative changes that occur during this period. Nearly 75% of Americans report losing both parents by their early 60s, and widowhood is fairly common for women in midlife (Aldwin & Levenson, 2001). Events involving losses that impinge on others' lives (e.g., injury to a child, job loss) are purported to be especially stressful during midlife (Aldwin, 1991), because they are both unwanted and unanticipated (Pearlin & Skaff, 1996; Thoits, 1995). Discrimination experiences are examples of life events that are often not included in traditional checklists. Discrimination has comparable associations with mental health as other stressors and, although more prevalent among people with disadvantaged social status, is common in the overall population as well (Kessler, Mickelson, & Williams, 1999).

Methods for Examining Interactions Among and Contributions of Many Stressors: RT and RF

Wheaton and Montazer (2010) make a compelling case for measuring diverse sources of stress and identifying their individual and combined effects. In this study, we utilize RT and RF analyses of a diverse set of chronic stressors and life events to further pursue these aims in order to understand interactions among stressors and the relative importance of specific stressful situations. RT and RF are examples of recursive partitioning approaches (Berk, 2010) to exploratory data mining, whereas in traditional regression, the goal is "to identify an *average* set of conditions associated with a given outcome" (Gruenewald, Mroczek, Ryff, & Singer, 2008, p. 332), tree-based methods such as these allow for *different* weightings of life events and chronic stressors for different individuals. Additionally, power constraints in traditional regression models require researchers to choose among the available predictors of interest and only test interactions among a subset of them.

In RT and RF, the researcher introduces less bias by not excluding predictors a priori because many predictors can be included, and the analysis selects those that are most informative. Finally, these models are particularly well suited to exploratory applications such as this one, in which there are numerous predictors of interest but prior research has not examined them in concert, so little is known about their additive or interactive effects.

Method

Participants and Procedure

Participants included 410 adults aged 37–64 years ($M = 52.12$; $SD = 6.18$) who completed the first survey of the longitudinal Notre Dame Study of Health and Well-Being. The sample is 59% women and is primarily Caucasian (86%), with Black/African American being the next most represented group (9%). The majority of participants were married (55%), with 25% divorced/separated and 20% single or widowed. In terms of education, 97% graduated from high school, with 37% earning a college degree; this translated into a representative income distribution, with 12.5% earning less than $15,000 annually, 9% earning between $15,000 and $25,000, 22% earning between $25,000 and $50,000, 34% earning between $50,000 and $75,000, and 22.5% earning more than $75,000 annually. Of the 439 participants who provided GPS data at this wave, 29 (approximately 7%) were missing on at least one of the predictors and were excluded from the data set.

Individuals were recruited from lists of middle-aged adults in the area provided by a market research firm. Each adult was mailed a packet of questionnaires that included stress measures. Upon returning their packets, participants received a $20 gift card.

Measures

Global perceptions of stress.—The 14-item PSS (Cohen et al., 1983) measures the degree to which individuals appraise the situations in their lives to be unpredictable, uncontrollable, and overloaded. Participants reflected about the last month and reported the frequency of agreement on a four-point scale (*never*, *sometimes*, *often*, and *always*).

A number of the predictors are subscales from the Wheaton Chronic Stress (WCS; Wheaton, 1997). WCS used 0 (*not true*) to 2 (*very true*) scale or N/A (*not applicable*). WCS includes questions on a variety of roles, some of which are mutually exclusive. Participants were instructed to only answer those questions that applied to them and mark N/A for others. Subscales were calculated with a 0 if not endorsed rule; for those people who were not in the role, their score was set to 0, not at all stressful. Five WCS items assessed *Parental role*, nine items assessed *Relationship problems*, three items assessed *Family problems*, four items assessed *Role inoccupancy and restriction*, five items assessed *Time pressure*, four items assessed *Finances*, and seven items assessed Work. Additional measures, described subsequently, were also included to more fully sample from the stressors across roles and domains.

Work.—Those who were working completed the 13-item Knox Work Stress Scale (Knox, Theorell, Svensson, & Waller, 1985). Participants endorsed items using a scale from 0 (*strongly disagree*) to 3 (*strongly agree*).

Caregiving.—Caregiving was assessed in two ways. First, participants indicated whether they were in a caregiving role and their relationship with the person (or people) being cared for. Responses were used as a categorical predictor describing focus of caregiving, referred to as Caregiver Type. Second, participants completed the 28-item Multidimensional Caregiver Burden Inventory (Novak & Guest, 1989) to which five items tapping positive feelings about caregiving were added for this study. Participants were asked to rate statements about their caregiving experience from 0 (*not at all true*) to 4 (*very true*).

Finances.—Financial stress was also assessed using five items used in the Midlife Development in the United States (MIDUS; Gruenewald et al., 2012). For four of the items, participants used a 0 (*worst possible financial situation*) to 10 (*best possible financial situation*) scale to rate their current financial situation, the amount of control over their current finances, and the amount of effort they put into their current finances. Participants then selected one response to describe their current finances ("We do not have enough money to meet our needs," "We have just enough money to meet our needs," and "We have more money than we need"). Responses to the items were standardized and summed.

Neighborhood.—Participants' ratings of their neighborhood were assessed using a 12-item scale developed based on research by Keyes (1998) and Ryff, Magee, Kling, and Wing (1999) and used in the MIDUS (Brim, Ryff, & Kessler, 2004). Items tapped multiple neighborhood features, including cleanliness, safety, and ease in calling upon neighbors for help. Participants responded on a 4-point scale, *strongly agree* to *strongly disagree*.

Loneliness.—Social isolation was measured via the 20-item UCLA Loneliness Scale (Russell, Peplau, & Cutrona, 1980). Respondents responded on a scale of 1 (*never*) to 4 (*often*). For purposes of clarification, one item was changed from the original (i.e., from "People are around me but not with me" to "I often feel alone even when in a crowd").

Chronic and somatic health problems.—Respondents reported on medical conditions and health problems using a checklist (Belloc, Breslow, & Hochstim, 1971). Fourteen

items assessed chronic health problems (e.g., hypertension, arthritis, and diabetes) and 15 items assessed somatic health complaints (e.g., joint stiffness, headaches, and tiring easily).

Life events.—Life events in the past year were assessed using a modified version of the Elders Life Stress Inventory (Aldwin, 1990). Participants endorsed the occurrence of 31 events across multiple domains including health, finance, family, and work.

Lifetime discrimination.—Participants reported whether each of 11 discrimination events (Williams, Yu, Jackson, & Anderson, 1997) occurred in their lifetime.

Analysis

Regression trees.—A goal of this study was to examine the unique interactions between the contextual variables associated with middle-aged adults generally perceiving their lives as stressful. We used RT, also called Classification and Regression Trees (CART; Breiman, Friedman, Stone, & Olshen, 1984). This analysis has been used in the adulthood literature to sort out interactions among many predictors (Gruenewald et al., 2008; Gruenewald, Seeman, Ryff, Karlamangla, & Singer, 2006; Scott, Bergeman, Whitehead, & Pitzer, in press; Scott et al., 2011). The software program CART Pro V6.0 (Steinberg & Colla, 1997) was used; RT can also be produced using free programs using R (R Core Development Team, 2012) packages such as *rpart* or *party*.

RT analysis begins with a *root node* containing the entire sample. Using a node splitting rule based on the selected RT algorithm, the software compares all the predictors across levels to determine the optimal predictor and its cutoff point. These are selected such that they minimize the within-group variance on the outcome, GPS. The analysis involves progressively performing these binary splits to divide the sample into smaller subsamples, called *nodes*, which group people who are more similar to one another than they are to the larger sample in the previous step. *Terminal nodes* at the bottom of the figure represent subsamples of individuals who cannot reliably be further divided based on the constraints. Prior to the analysis, the researcher sets limits regarding when to stop splitting. One example is to set a minimum number of cases in a terminal node; this constraint also limits tree complexity by not allowing the tree to grow to the extreme in which each person is represented by a different terminal node. Minimum terminal node size was set to 10.

Because of the exploratory nature of the analysis, procedures are employed to reduce the likelihood that the tree structure and interactions produced are overly influenced by the nuances of the sample (Berk, 2010; Breiman, 2001). This analysis followed the procedures in an earlier paper (Scott et al., 2011), including RF to identify the most influential predictors across many trees. Variables were standardized prior to analysis to aid in interpretation.

Random Forests

Individual trees are sensitive to the particularities of the sample and the variables available; small changes in the participants, splitting variables, or cut points may result in trees with very different structures (Strobl, Malley, & Tutz, 2009). The 10-fold cross-validation technique employed in the RT analysis is one way to limit this tendency to overfit the data. RF (Breiman, 2001), an extension of RT, take advantage of this sensitivity and resulting variability by aggregating across multiple trees to produce more stable results. Two sources of variation are imposed on the data set in RF. *Bagging* (i.e., bootstrap aggregating) bootstraps the participants to vary the sample and then aggregates the predictions of these models (i.e., trees) into a single prediction. The models are weighted by their performance on the data that were not chosen at each bootstrap. In so doing, RF repeatedly draw from the sample and analyze the remaining data in order to estimate how well the models generalize. Additionally, predictors are sampled with replacement. This is an especially important feature because it allows for contributing variables and interactions that might be missed when particularly strong predictors (e.g., loneliness, based on our research with older adults) or substantially correlated predictors (that overlap but also retain unique content, e.g., two scales indexing work demands) are in the mix (Berk, 2010). Although RF produce too many trees (i.e., 500 in this analysis) to interpret individually, they provide indices of variable importance across the forest of trees (Strobl, Malley et al., 2009).

The *cforests* procedure in the party package in R (Hothorn, Buhlmann, Dudoit, Molinaro, & Laan, 2005; Strobl, Boulesteix, Kneib, Augustin, & Zeileis, 2008; Strobl, Boulesteix, Zeileis, & Hothorn, 2007) was used to conduct the RF analysis. We specified constraints of at least 10 participants per node and for bagging (subsampling.632 × *n*), number of trees (ntree = 500), and sampling from the predictors (mtry = 5). We followed recommendations (Strobl, Hothorn, & Zeileis, 2009; Strobl, Malley et al., 2009) to address sample size and correlated predictors. *Permutation importance* describes the extent to which the accuracy of a contextual risk variable in predicting GPS decreases when the risk variable is randomly permuted or shuffled. The ranking of variables relative to each other is the focus of interpretation, rather than their absolute values.

Results

Descriptive Statistics

Descriptive statistics and correlations are provided in Table 1. All stressors except discrimination and chronic

Table 1. Means, Standard Deviations, Correlations, and Alphas of Variables in the Full Sample ($N = 410$)

	M	*SD*	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1. Loneliness	39.25	11.27	*.93*																
2. WCS relationship	2.47	3.54	**.20**	*.90*															
3. WCS family	1.44	1.57	.03	**.20**	*.52*														
4. WCS parent	1.87	2.20	**.27**	**.28**	**.24**	*.93*													
5. Caregiver burden	7.24	13.90	**.11**	.06	.09	**.19**	*.88*												
6. WCS role strain	1.59	2.05	**.50**	**.13**	.05	**.14**	**.12**	*.81*											
7. WCS time	2.50	2.11	**.22**	**.37**	**.14**	**.29**	**.23**	**.21**	*.71*										
8. WCS work	3.00	2.67	**.22**	**.29**	.07	**.22**	.05	**.15**	**.41**	*.72*									
9. Knox work	13.58	7.56	.08	**.15**	**−.11**	−.03	−.02	−.07	**.27**	**.50**	*.83*								
10. WCS income	2.86	2.13	**.32**	**.22**	**.16**	**.36**	**.30**	**.34**	**.29**	**.30**	−.05	*.70*							
11. Financial stress	0.004	2.83	**.29**	**.13**	**.14**	**.30**	**.14**	**.25**	**.14**	**.14**	**−.19**	**.62**	*.67*						
12. Neighborhood strain	21.92	5.88	**.34**	.04	.07	**.15**	.04	**.30**	.09	.08	−.06	**.29**	**.33**	*.90*					
13. Life events	5.69	2.61	**.22**	**.28**	**.25**	**.30**	**.20**	**.23**	**.33**	**.20**	−.09	**.34**	**.30**	**.17**	—				
14. Discrimination	1.98	1.90	**.13**	.08	.07	**.15**	**.21**	**.15**	**.17**	**.11**	−.03	**.28**	**.23**	**.17**	**.24**	—			
15. Somatic health	2.24	2.06	**.22**	**.14**	**.13**	**.21**	.08	**.25**	.08	.04	**−.17**	**.24**	**.30**	**.27**	**.38**	**.28**	—		
16. Chronic health	1.26	1.35	.02	.03	**.12**	**.15**	**.12**	.07	.01	−.07	**−.19**	**.15**	**.15**	**.21**	**.23**	**.15**	**.53**	—	
17. GPS	32.23	5.80	**.57**	**.20**	**.21**	**.35**	**.18**	**.30**	**.38**	**.32**	**.14**	**.36**	**.37**	**.25**	**.29**	.09	**.26**	.08	*.88*

Note. Cronbach alphas for scales are provided on the diagonal; reliabilities are not calculated for the count data. The Financial Stress scale comprised standardized items. The scales for Life Events, Discrimination, Chronic Health, and Somatic Health reflect counts of exposure or symptom reports. Significant correlations are in bold. Reliability alphas for each scale are presented on the diagonals, in italics. GPS = global perception of stress; WCS = subscale from the Wheaton Chronic Stress scale.

health correlated with GPS. Older age was associated with lower PSS ($r = -.11$). Gender and race were unrelated to GPS; however, higher SES participants tended to report lower GPS (e.g., income $F(6, 400) = .62$, $p < .01$; education $F(7, 402) = 5.35$, $p < .01$). Marital status was also related to GPS ($F(4, 202) = 3.23$, $p < .02$); those who were separated or widowed reported higher perceived stress.

Regression Tree

RT were used to identify the patterns of splits on stressors that led to node membership (Figure 1). Based on Table 2 correlations, loneliness explains about 32% of the variance in GPS. These zero-order correlations, however, do not incorporate the relationships among events and chronic stressors and how these relate to GPS. Further, these correlations assume the same relationships for all people in the sample. Our interest was on the diversity of pathways that might describe perceived stress in midlife; thus, we focused on a technique that allows different predictors and cut points for different people in the sample. The tree in Figure 1 explains 45% of the variance in GPS.

The most straightforward reading of Figure 1 begins at the top (Root Node 1) and follows the individual paths to the bottom of the figure to understand the unique interactions between predictors in describing different levels of perceived stress. The root node contains the entire sample; because all the variables are standardized, the sample mean for GPS is 0 with a 1 *SD*, and the split points indicate number of standard deviations from the sample mean on that predictor.

Partitioning the sample by lower (Node 2) and higher levels (Node 3) of loneliness aids in separating those with below average levels of perceived stress (Node 2) and those with much higher levels (Node 3). Within this grouping, loneliness can further distinguish those with lower (Node 4) from those with more average levels (Node 5) and those with moderate levels of perceived stress (Node 6) from those reporting very high levels of perceived stress (Node 7).

These loneliness groupings of perceived stress can be further distinguished by interactions with other variables. For example, among those reporting the least loneliness, higher parent role demands distinguish those in Node C from those in Nodes A and B whose work role can be used to separate their moderately low global perceived stress (Node B) from those with perceived stress nearly 1 *SD* below the sample average (Node A). Among the participants with medium to low levels of loneliness (Node 5), work role is also informative in separating those with below average levels of perceived stress (Node D) from those with average to moderate levels (Node E).

In the higher loneliness branches of the tree, different predictors were useful in describing perceptions of life stress. Among those with medium to high loneliness (Node 6), family role separates those with relatively high levels (Node H) from those with more moderate perceptions of life stress (Node 9). Within this moderate to high loneliness and low family stress group, there is still substantial diversity in levels of perceived stress. Income demands help to partition those who, despite their loneliness, have relatively low levels of perceived stress (Node F) from those with above average perceptions of life stress (Node G). Those in the highest loneliness branch of the tree (Node 7) report very high levels of perceived stress overall, over 1 *SD* from the average person in the sample. The interaction between

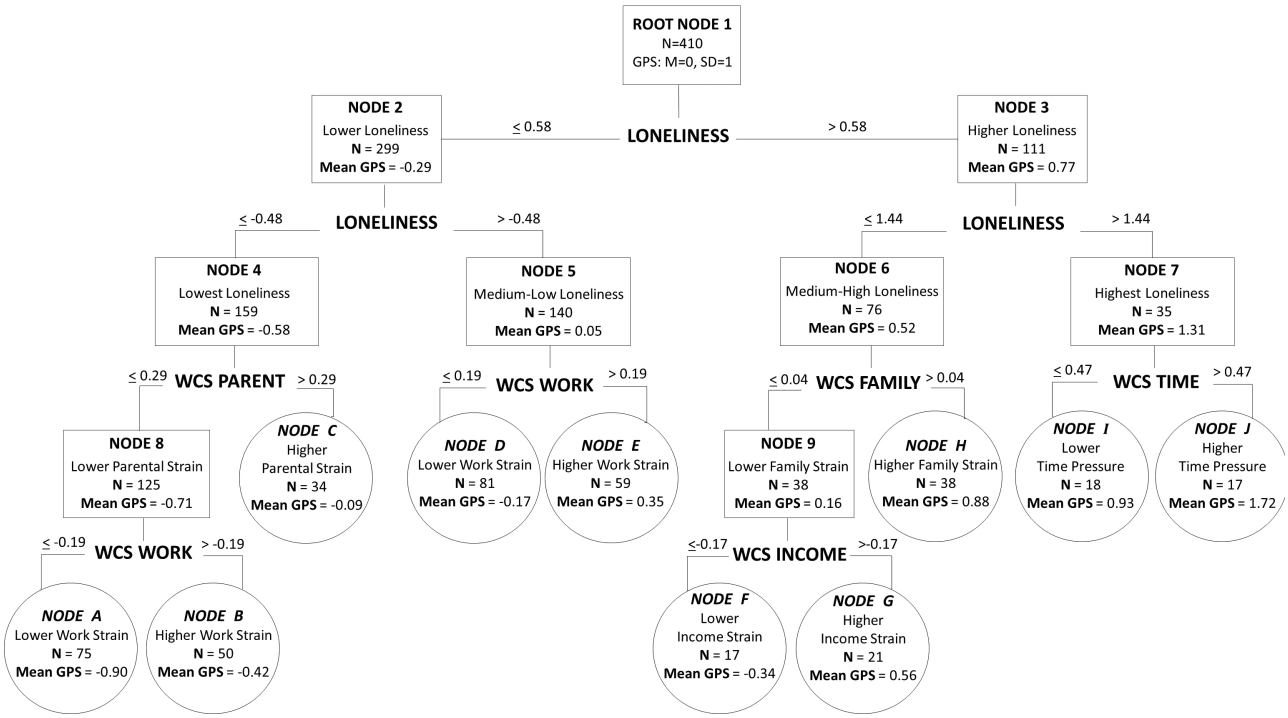

Figure 1. Perceived stress regression tree. Root and child nodes are displayed in boxes; terminal nodes are displayed in circles. Splitting variables are indicated at the intersection of branching lines. For each node, cut point on the splitting variable, number of participants in that node, and perceived stress mean and standard deviation are reported. GPS = Global Perceived Stress outcome, measured by the Perceived Stress Scale; WCS PARENT = Wheaton Chronic Stress Scale parent role; WCS WORK = Wheaton Chronic Stress Scale work role; WCS FAMILY = Wheaton Chronic Stress Scale family role; WCS INCOME = Wheaton Chronic Stress Scale financial strain; WCS TIME = Wheaton Chronic Stress Scale time/pressure.

this high loneliness and time pressure made it possible to distinguish very high levels of perceived stress (Node I) from extreme levels of GPS (Node J).

Random Forests

RF results (Figure 2) provided information on the relative contribution of each stressor domain in predicting GPS. Loneliness was clearly the strongest predictor, even when the composition of the sample and available variables were varied across 500 possible trees. This indicates that randomly shuffling the values of loneliness breaks the association between loneliness and perceived stress; variables that are only weakly related to perceived stress are not significantly affected by this shuffling. When this shuffled version of loneliness is used with the other events and stressors to predict GPS, the tree's prediction accuracy is substantially diminished. Finances, work, parent role, and time pressure were relatively similar in conditional permutation importance, not as high as loneliness, but consistently the next highest permutation values. Small effects were found for somatic health, life events, neighborhood, work, role restriction, income, and family.

Discussion

This study examined a diverse set of chronic stressors and events from across life domains and, using a relatively novel approach of RT, identified combinations among these predictors relating a sample of middle-aged individuals' perceptions of their current lives as stressful. Further, RF results provide the relative contributions of each predictor. These results link to a rich theoretical literature emphasizing the importance of considering individuals and stressors in their contexts. Finally, using GPS as an outcome provides evidence for the (a) stressful contexts that contribute to a commonly used predictor of psychological and physical health and (b) diversity of the combinations of stressors related to similar levels of GPS, relevant for intervention. Subsequently, we highlight this approach's strengths for examining theoretical concepts, particularly the insights that would not be possible with traditional techniques. We also detail the limitations and note important next steps in testing stress theory.

Examining Multiple Stressors Together

The RT results provide a snapshot of diverse, complex, and demanding lives. Concurrent, interconnected stressors were posited by stress theorists and have been examined in a limited way (i.e., interactions between daily events and chronic health stressors (Potter & Zautra, 1997) or relative impact of stressor type aggregated across life domain (Wheaton & Montazer, 2010) using traditional techniques. The nonparametric tree-approach advances on this study by documenting interactions among predictors sampled from

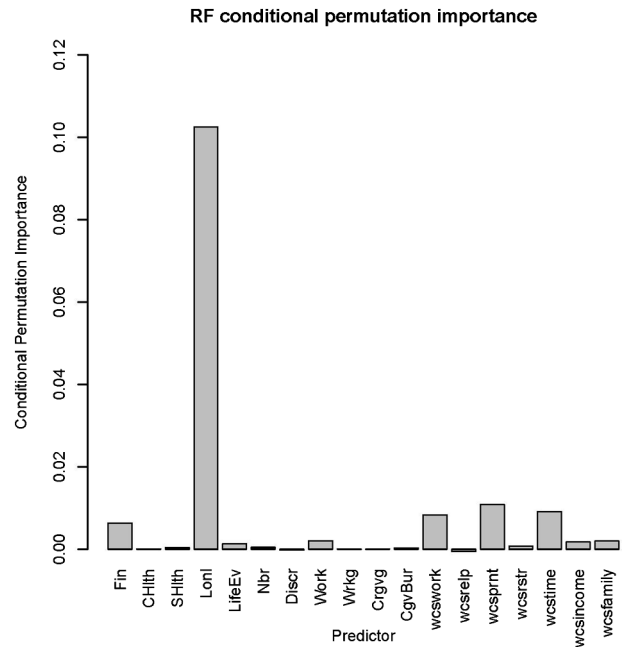

Figure 2. Random forest conditional variable permutation importance results. Outcome variable: Global Perceived Stress as measured by Perceived Stress Scale. Wrkg = work status (0: not working, 1: working), categorical; Care = caregiver status (0: not a caregiver, 1–7: caregiver type), categorical; Fin = financial strain; CHlth = chronic health problems; SHlth = somatic health problems; Lonl = loneliness; LifeEv = life events; Nbr = neighborhood strain; Discr = lifetime discrimination experiences; Work = Knox work strain; CgvBur = caregiver burden. The following predictors are subscales from the Wheaton Chronic Stress Scale (Wheaton, 1997): wcswork = Wheaton Chronic Stress work strain; wcsrelp = Wheaton Chronic Stress relationship problems; wcsprnt = Wheaton Chronic Stress relationship problems subscale; wcsrstr = Wheaton Chronic Stress role restriction; wcstime = Wheaton Chronic Stress time pressure; wcsincome = Wheaton Chronic Stress financial problems; wcsfamily = Wheaton Chronic Stress family role.

diverse life domains. In some ways, Figure 1 shows a theoretical metaphor evidenced in data; the complicated ways in which stressors co-occur to produce GPS can literally be seen. The connected nodes displaying interactions between stressors resonate with Pearlin's constellation metaphor used to describe linked stressors. It also fits well with the pathways approach which grounds developmental psychopathology theory, which uses a tree metaphor (Sroufe, 1997); indeed, substantive researchers have described the interactions produced by RT as pathways (Gruenewald et al., 2008).

Regardless of the metaphor chosen, the RT results provide evidence for multifinality and equifinality. An example of multifinality, Nodes F and E report moderate loneliness within 0.5 *SD* above and below (respectively) the mean, but pressures (or lack thereof) from work, family, and income interact such that the more lonely individuals report lower GPS. Nodes H and I are an example of equifinality—although they differ in loneliness, they report similar GPS. The interactions between moderate to high loneliness with above average family demands (Node H) and very high loneliness with low to moderate time demands (Node I) produce these similar scores. In both examples, these interactions are missed in the bivariate correlations in Table 1 and may not have been apparent in traditional regression models that provide the average interaction effects across the entire sample.

This level of detailed description comes with the recognition that individual trees are sensitive to the characteristics of the sample, the constraints put on the analysis, and the variables supplied to it. Split sample techniques, not possible here given the sample size, can be used to increase the generalizability of the results; the 10-fold cross-validation used here has a similar purpose. Finally, results from the CART program produce a number of possible trees to describe the data and suggest a range of trees that are within 1 *SD* of the nominated tree. Researchers must choose among the trees based on the research question and theory (Berk, 2010).

According to Wheaton and others, it is necessary to sample the stress universe in order to understand the effects of stress on health and well-being. RT depict the intricate interactions in predicting perceived stress for a specific sample, whereas RF permutation results give information about the relative contributions of each of the stressors included. This is a key strength of RF over the results from traditional approaches, which have been more limited in the number of predictors that can be considered in the same model. Further, RF build confidence in the generalizability of the results by aggregating over trees built from varied subsamples of the participants and variables. Keeping in mind the combinations of stressors displayed in RT, these RF results can also help refine future examinations of individual stressors. For example, given that GPS moderates emotional responses to daily stressors (Sliwinski et al., 2009; van Eck et al., 1998), it would be interesting to probe the extent to which this is due to loneliness, the primary predictor identified by RF. An analysis of diary or burst data could include both GPS and loneliness as person-level or wave-level predictors to better understand how broader psychosocial conditions affect the effect of day-to-day events on mood, physical symptoms, or even the occurrence of daily interpersonal conflicts.

Stress Proliferation and Other Important Topics

The results demonstrate that significant stressors rarely occur in isolation. In reviewing studies examining combinations of stressors, Thoits (1995, p. 57) speculated that these were "actually capturing the effects of particular event and strain sequences." Although not possible to examine in this cross-sectional analysis, these combinations could stem from *stress proliferation* (i.e., one event leading to another; Pearlin et al., 1981; Pearlin, Aneshensel, & LeBlanc, 1997). This cross-sectional limitation is particularly important to keep in mind given that RT interactions have been described using process terms such pathways and that trees resemble flow charts of ordered steps. Future studies, either designed with this in mind or thoughtful

secondary data analysis of longitudinal data sets, could take advantage of other related approaches such as trajectory mining. These have been used to identify sequences of occupational transitions (e.g., events) and which sequences are more typical of men and women (Widmer & Ritschard, 2009). An exciting possibility would be to apply these techniques to longitudinal or other intensive measurement data to identify series of stressors. This would enable researchers to document stress proliferation as well as how specific series relate to a later well-being outcome as evidence for cumulative stress.

It is also important to note that this study focused on chronic stressors and life events but not on protective resources, genetic predispositions, or early experiences. RT have been used to examine interactions among theorized resources, including competencies predicting child depression symptoms (Seroczynski, Cole, & Maxwell, 1997) and protective factors predicting psychological well-being among older adults (Wallace, Bergeman, & Maxwell, 2002). Relatedly, diathesis–stress models (Monroe & Simons, 1991; Zuckerman, 1999) posit that some individuals carry vulnerabilities that make stressors more impactful. Future work may examine interactions among stressors, person characteristics (i.e., genetic diatheses, personality), and resources together; the purpose of this study was to first document the constellations of stressors and their relative influence.

Limitations and Future Directions

The diverse pathways to perceived stress and the consistent influence of loneliness provide implications for theory, research, and practice; yet, several limitations should be noted. The sample is representative of the Midwestern area from which it draws; generalizability to more diverse U.S. samples or international samples may be limited. Varying the sample composition, as done through RF, is one way to simulate possible differences. Second, although trees in Figure 1 look like cascading stress proliferation, the analyses are cross-sectional and require repeated measures to delineate temporal ordering of stressor exposure that may produce GPS. Future studies will test, rather than solely conjecture on, stress proliferation, compensatory processes, and diathesis–stress. Although these phenomena cannot be examined directly here, the findings contribute to the growing momentum to more thoroughly acknowledge the complexity of individuals' lives and use research approaches that accommodate this intricacy. Third, although the study employed a relatively large number of predictors from a range of life domains available in the data set, some important other examples of stressors (i.e., early adversity, daily events) at midlife were not included.

The findings encourage researchers to think about how multifaceted demands of midlife produce individual differences in GPS. Even among people expressing similar levels of loneliness, GPS reports differ in part because of the varying demands from work, family, and finances. Examples of equifinality are also important, as they indicate considerable variability in the contributing factors that result in similar levels of perceived stress. This study encourages theorists, researchers, and clinicians to think about persons as nested in their life contexts of their health, finances, relationships, work, neighborhoods, and event histories and describes a relatively novel approach to testing concepts from stress theory.

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