NEGATIVE AFFECT AND STRESS:
A DYNAMICAL SYSTEMS ANALYSIS

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Abstract
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In the vast literature of developmental psychology, there is a great deal of conceptual debate surrounding definitions of resilience, change, and process. It is argued that at the interface of theory and method lies a unique opportunity to develop our notions of resilience-as-process, test these using newer analytical techniques such as Dynamical Systems Analysis (DSA), and, therein arrive at better elaborated theoretical depictions of development that may, in turn, beg for ever more sophisticated methods for capturing and analyzing change. In the present study, resilience is defined as the human capability to resist, cope with, recover from, and succeed in the face of adverse circumstances (Masten & Powell, 2003), with adversity defined as the myriad stressors individuals encounter as they age. As individuals develop, age-related stressors abound, and the ability to manage one’s emotions has been suggested as a fundamental component of maintaining well-being in the face of this stress. The present study examined the lived experience of elders, and investigating first the daily dynamic experience of negative affect (NA), and its relationship to a person’s general proclivity toward negative emotionality (i.e., a stable negative emotional equilibrium). After this relationship was described, the focus shifted
toward understanding the predictors or correlates of daily fluctuations in NA from a resilience perspective. Finally, within the stress-and-coping framework, resilience is understood as a process whereby resilience resources intervene in the relationship between the experience of stress and feelings of well-being. Therefore, the relationship between daily perceived stress and daily NA was examined. After understanding the extent to which these experiences tend to be tied together (in terms of strength and nature of coupling), second order models were used to explore the extent to which resilience resources predicted the parameters of association between changes in NA and in Stress.
This dissertation is dedicated to all of my family and friends… for it is in relationship that we create the world we wish the rest of the world to be.
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One of the themes undergirding my time in graduate school is that knowledge and understanding come from multiple sources – from quantitative models and life story interviews, from within Psychology and from without. In particular, graduate study has afforded me the opportunity to recognize and explore relationships – between theory and method, within and across disciplines, between the academy and the world we strive to understand. It is for the relationships that spur and sustain this exploration that I am most grateful.

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INTRODUCTION

From a life span developmental perspective, forces of growth and decline vie in a productive tension, from which human psychological development emerges (Baltes, 1987). The theory-method interface is yet another continual dance, this time between theoretical propositions and the methodological techniques designed to test and further them, that gives rise to increasingly sophisticated models of emergent development (Nesselroade, 2006; Nesselroade & Schmidt McCollam, 2000). In describing this dance, Nesselroade (1988) contends:

First, substance, often in the form of elaborate but untested theory, takes a step and then methodological developments follow. Subsequently, methodology may glide out ahead, even far ahead of substantive gains. The partners in this seemingly cumbersome dance likely will never blend in a graceful pas de deux. Nor should we wish them to. Rather, a continuing imbalance seems to enable each in turn to elicit new steps from the other. (p. 643)

Resilience research, the study of intraindividual plasticity in developmental processes, is one arena of life-span developmental theorizing that has benefited from the exertions of this dance (Bergeman & Wallace, 2006). From its inception as a theoretical construct (Garmezy, 1971; Werner & Smith, 1982), resilience has been explored as a trait (Garmezy, 1971; Werner & Smith, 1982), a process (Egeland, Carlson, & Sroufe, 1993), and as both trait and process (Masten, Best, & Garmezy, 1990; Ong, Bergeman, Bisconti, & Wallace, 2006). The extant resilience literature provides a firm foundational understanding of long-term trends in adaptive functioning, and has yielded insight into factors mitigating the experience of life stress and subsequent adaptive functioning. In the
natural evolution of scientific investigation, however, “successful scientific disciplines proceed from description and static formulation to dynamic ones” (Nesselroade & Schmidt McCollam, 2000, p. 296). With regard to one component of resilient functioning, this progression can be traced over the past decade: macroscopic investigations of subjective well-being have given rise to micro-analytic studies of individuals’ daily lived experience. To this end, continuing methodological advances such as those in Dynamical Systems Analysis invite researchers to join in the quest to advance powerful models of evolving developmental processes (Boker, 2002), and, in doing so, to refine their theoretical notions of resilience.

Theoretical conceptions of resilience in human psychological development.

Resilience has been discussed in many ways, both as a characteristic and as a process. Lerner’s (1984) notions of plasticity and flexibility speak to a process-oriented view of resilience. Arguing from the contextual world view of development, he posits that plasticity is found in developmental processes which, by necessity, entail transactions between the developing individual and the context in which s/he is developing. That is, developmental processes themselves are plastic in that they are malleable, and shift according to the facilitative or constraining influences of both one’s personal characteristics and one’s social and environmental contexts. Flexibility, on the other hand, is the result of these plastic developmental processes, and involves “the ability to change self and/or context to meet the demands of life, and the ability to attain a ‘good fit’ with the context” (p. 12). Although individuals can be labeled “resilient” relative to one another (according to the extent that they characteristically use this
flexibility to cope with life stress), flexibility also pertains to the process by which individuals exercise this ability, that is, the process by which they alter themselves or their contexts in order to successfully navigate life’s challenges.

It is this latter notion of flexibility that defines “resilience” for many researchers today. This multifaceted conceptualization of resilience corresponds nicely to a now classic definition offered by Masten, Best, and Garmezy (1990): “resilience refers to the process of, capacity for, or outcome of successful adaptation despite challenging or threatening circumstances” (p. 425). These definitions do little, however, to tease apart the questions concerning whether resilience refers to some romantic quality of invincibility, or instead represents a process of coping successfully with stressful life circumstances. The definitions fail to speak, as well, to the level of risk necessary for a given process of adaptation to be considered resilient. Regarding this notion of risk, Cummings, Davies, and Campbell (2000) ask a compelling question: “If it is accepted that psychological development is generally resilient, then why should resilience be limited to only certain groups?” (p. 128).

As data on both adaptation and maladaptation to stressful life circumstances increasingly become available, one of the emerging themes in the study of human development is that resilience is more common than once believed (Bonanno, 2004). Whereas early work focused on “invulnerability” and other rather herculean individual characteristics (Garmezy, 1971; Werner & Smith, 1982), contemporary resilience research focuses instead on more common processes that allow individuals to adapt well to stress (Cummings, et al., 2000; Lazarus & Folkman, 1984). Henceforward, resilience is considered here to be the human ability to resist, cope with, recover from, and succeed
in the face of adverse circumstances (Masten & Powell, 2003). As “ordinary magic,” resilience is the result of the normal functioning of human adaptational systems (Masten & Powell, 2003, p. 15), and is often construed in the aging literature as maintenance of health and well-being despite the stresses accompanying advancing years (Bergeman & Wallace, 1999).

_resilience as the maintenance of well-being in the face of stress._

One of the variables thought to be most impacted by the experience of stress is a sense of well-being. According to the stress-and-coping framework, individuals who experience less stress, or whom use resources effectively to manage stress, will experience better health and well-being outcomes than their more stressed or ineffectually-coping counterparts (see Lazarus & Folkman, 1984). There is, however, a great deal of conceptual debate surrounding the notion of well-being. Is well-being simply the absence of negative emotions, or is it instead an extant psychological good (e.g., positive emotionality) to be cultivated in its own right? Although the debate continues, Diener suggests that subjective well-being is a broad concept that emerges from the experience of pleasant emotions, low levels of negative emotionality, and high levels of life-satisfaction (Diener, 1984; Diener, Lucas, & Oshi, 2002; Deiner, Suh, Lucas, & Smith, 1999). Although previous conceptualizations treat subjective well-being monolithically, Diener and colleagues (1999) convincingly argue that each conceptually distinct component relates differently to adaptation, thus suggesting that the components of well-being are perhaps best studied individually, at least initially, rather than in confluence. Therefore, the present empirical investigation focuses on understanding the
process of adaptation with regard to negative affect, one component of well-being; remaining important theoretical considerations will be explored in the process of reviewing the empirical literature regarding this relationship.

The role of protective factors in facilitating the resilience process.

Proponents of the life-span developmental tradition view human development as an enduring struggle between forces of growth and decline (see Baltes, 1987), and mounting evidence suggests that although significant, self-relevant losses are nearly universal in the aging process, many older adults adjust well, reporting high levels of well-being (Lawton, Kleban, & Dean, 1993). Supporting the contention that resilience is more common than once believed, this finding begs the question: how does the “ordinary magic” of adaptation to life stress arise?

In exploring resilience, Masten and Reed (2002) note that an important component to assessing resilience is to examine “the qualities of individuals and their environments that might explain why some people fare better than others in the context of adversity” (p. 77). This includes identifying and understanding what they term assets, resources, and protective factors. Assets, as opposed to risk factors, are factors that, when present, are associated with better adaptation in one or more domains and are independent of level of risk. Resource refers to any capital, be it human, social, or material, used in the process of adaptation. Protective factors, according to Masten and Reed, are personal or contextual qualities that are associated with better adaptation when risk or adversity is high, and are, accordingly, utilized in protective processes, which are the processes by which individual development succeeds despite threat. Masten’s definition of protective
factors (i.e., those variables or processes that are associated with decreased probability of a negative outcome, or complimentarily, increased probability of better-than-expected outcomes; Masten & Powell, 2003), is generally accepted, although many researchers disagree as to whether risk is a necessary precursor in the elicitation of resilience. Two categories of protective mechanisms have been described: personal and community/social support factors.

*Personal protective factors* are dispositional attributes (e.g., personality characteristics) that contribute to stress management (Bergeman & Wallace, 1999). Personal protective factors are ubiquitous – cognitive and social skills, as well as flexibility in encountering new situations all facilitate adaptation to stress (Garmezy, 1991). One construct thought to be especially important in the management of life stress is *dispositional resilience*, the characteristic way in which a person encounters and interprets stressful experiences (Bartone, Ursano, Wright, & Ingraham, 1989). This global construct comprises three components, all of which have been shown to aid in the coping process: control, commitment, and challenge.

*Control*, in the dispositional resilience literature, is “a sense of autonomy and ability to influence one’s destiny” (Bartone, et al., 1989, p. 319), and is conceptually similar to self-efficacy. This type of control may influence an elder’s response to stress in many ways, including 1) influencing the extent to which an elder views an event or circumstance as stressful or threatening, 2) by modulating subsequent physiological responses to that event (e.g., elevated blood pressure), and 3) offering general protection from the detrimental sequelae of stress (Ben-Zur, 2002; Lazarus & Folkman, 1984; Pearlin & Schooler, 1978; Rodin, 1986). A sense of self-efficacy may aid the adaptation
process by influencing an elder’s decision concerning whether to act to change an unfavorable situation, how much effort to put forth, and how long to sustain action in the face of obstacles or continued strife (Bandura, 1977). Although there is still much debate surrounding the nature of the control construct in the elderly (cf., Skinner, 1996), a sense of control has been reliably linked to sustained or increased well-being in the face of adversity (Lachman, 1986; Lachman, Ziff, & Spiro, 1994; Rodin, 1986).

Although commitment, “a sense of meaning and purpose imputed to one’s existence encompassing self, others, and work” (Bartone, et al., 1989, p. 319), is not studied extensively in the literature, it is conceptually similar to Conscientiousness, one of the Big Five personality characteristics. Similarly, challenge, “a kind of zest for life and living that leads one to perceive changes as exciting and as opportunities for growth rather than threats to security and survival” (Bartone, et al., 1989, p. 319; Maddi & Kobasa, 1984), bears striking conceptual resemblance to Openness to Experience. Despite the intuitive appeal of these characteristics to conceptualizations of resilience resources, there exists little empirical literature on their role in maintaining or fostering well-being (Headey & Wearing, 1989; Schmutte & Ryff, 1997).

In the extant literature, Conscientiousness has been found to be inversely related to negative affect, perhaps because the achievement fostered by high levels of this trait may contribute to a better quality of life and more overall satisfaction with life (McCrae & Costa, 1991). Openness to Experience has been shown to be reliably, although modestly, related to the experience of both positive and negative affect (Costa & McCrae, 1984; Heady & Wearing, 1989; McCrae & Costa, 1991); interestingly, it has been considered by some to be a double-edged sword: rather than attenuating negative affect,
the positive direction of the effect suggests that individuals high on this trait tend to be more open and responsive to negative, as well as positive, experiences (McCrae & Costa, 1991). In contrast, Watson and Clark (1992) found that individuals higher in Openness to Experience experienced less negative affect. Because highly open individuals are very responsive to nature and art (McCrae, 1993-94), they may harness these heightened perceptions of beauty to manage or resolve negative affect (Ackerman, 2002).

All three components of dispositional resilience (i.e., control, commitment, and challenge) have been shown to foster resilient functioning independently, as has the composite construct, also called hardiness. As a constellation of three protective factors working in concert, the composite construct succinctly describes an individual’s characteristic manner of interpreting and resolving challenging life circumstances (Bartone, et al., 1989). Studies have found that individuals higher in dispositional resilience are less affected by increases in stress (Orr & Westman, 1990), experienced less distress in situations of sustained challenge, such as caregiving (Bartone, et al., 1989; Clark & Hartman, 1996), and generally experience less distress and dissatisfaction with life (Clark & Hartman, 1996). It is clear that dispositional resilience, investigated alone or in concert with its counterpart resilience resource, social support (Ganellen & Blaney, 1984), arbitrates the relationship between stress and well-being, and emerges in the literature as an important component of the stress-and-coping process (Wallace & Bergeman, 2007), particularly with regard to the psychological distress inherent to negative affect.

In contrast to the internal nature of personal protective factors, community/social support factors are often considered exogenous to the developing individual. These
external supports include affectional ties between family that provide support through stressful times and extrafamilial supports such as friends, community organizations, and socioeconomic factors (Bergeman & Wallace, 1999). Werner (1989) speculated that these support factors facilitate adaptation by supplying a system of beliefs by which to live and make sense of the world, as well as by rewarding individual competence and determination. Thus, social support has garnered much of the attention in the literature as a fundamental resource on which individuals call to manage the stressors of aging (Antonucci & Akiyama, 1991).

There has been considerable debate, however, concerning the role that social support plays in the maintenance or return to well-being (Adams & Blieszner, 1995; Antonucci & Akiyama, 1991; Cohen & Wills, 1985). Some studies show that social support has a main effect on well-being – meaningful social connections are associated with positive mental health outcomes, independent of experienced stress. Other studies support an indirect, buffering role of social support such that it is in the interaction between stress and social support that well-being is affected; that is, individuals benefit from relationships only when they use that social connectedness to manage stress. Rather than competition between the models, empirical research supports both hypotheses (Adams & Blieszner, 1995; Cohen & Wills, 1985). As with personal resources such as control (Ben-Zur, 2002; Lazarus & Folkman, 1984; Pearlin & Schooler, 1978; Rodin, 1986), social support may intervene in the stress-and-coping process in several ways: 1) having the sense that others are there to assist in bearing the burden of stress may mitigate the extent to which an event is appraised as stressful, 2) members of a support network may assuage feelings of stress before those feelings impact affect, or 3)
supportive persons may directly intervene to ameliorate the stressful situation (Cohen & Wills, 1989). \(^1\), \(^2\)

*Expanding notions of resilience-as-process using micro-analytic techniques.*

Although the importance of both concurrent and longitudinal relationships between stress and negative affect, as well as different protective mechanisms as mitigating factors in those relationships, cannot be overstated, these findings may represent a first generation of inquiry. “Depictions of occasion-to-occasion and age-to-age average changes and the stability of rank order (e.g., as in using test-retest correlation coefficients), interesting though they may be from a descriptive point of view, can point to process in only limited ways” (Nesselroade & Schmidt McCollam, 2000, p. 295).

Molenaar, De Gooijer, and Schmitz (1992) expand on this theme: “In general, each macroscopic description of longitudinal processes can be refined and extended through micro-analytic studies of the dynamic sources underlying these processes” (p. 334).

A foray into the affect literature shows quite clearly that the quest to understand and refine notions of well-being using micro-analytic techniques has been an unfolding developmental process itself, with innovative use of existing methods allowing for the

\(^1\) As a caveat, it must be noted that like Openness to Experience, social support is thought to be a double-edged sword: although social support has a fairly well-documented role as a resilience resource, membership in families and friendships brings with it additional stress, and, possibly, reward for maladaptive behavior (Rook 1984).

\(^2\) Important to note as well, is that indicators of the quality of an individual’s support network has been more predictive of well-being in older adults than mere network size (Antonucci & Akiyama, 1991; Jang, Haley, Small, & Mortimer, 2002). The suggestion that the quality of the support network is more salient that then quantity of support accords with socio-emotional selectivity theory, a leading theory of social and emotional development (Carstensen, 1995). According to this theory, older adults pare down their social interactions, increasing the number of exchanges with others with whom they have close, affectional ties and limiting less meaningful contact.
generation of increasingly sophisticated models of adaptation. A common theme in micro-analytic studies of affect is that the ability to manage one’s emotions is an especially important part of well-being (Staudinger, Marsiske, & Baltes, 1993), and that one component of successful adaptation to aging or specific life events is this ability to keep affective experience within reasonable emotional bounds (Bisconti, Bergeman, & Boker, 2004; Kesseler, Price, & Wortman, 1985). Understanding the way in which emotions are used and managed in daily lived experience may aid in interpreting and extending the results of macroscopic descriptions of the stress-and-coping process.

In a cross-sectional examination of daily emotional experience across the lifespan, Carstensen, Pasupathi, Mayr, and Nesselroade (2000) found that the frequency of experiencing positive affect remains stable across the adult life course, whereas negative affect declines with age until 60, when the decline levels off. Adaptive emotion regulation was defined here as the extent to which participants either experienced more positive affect or less negative affect relative to their normal reported levels of each (i.e., mean positive affect and mean negative affect). Relative to two younger age cohorts, older adults were found to have greater stability in the maintenance of highly positive affective states and of low negative affective states.

Although the study above is an important contribution to the literature for its investigation of patterns of daily emotional experience across the life course, more sophisticated operational definitions of emotion regulation better speak to notions of process. Several recent papers (Ong & Bergeman, 2004; Ong, Bergeman, & Bisconti, 2004; Zautra, Affleck, Tennen, Reich, & Davis, 2005) employ new applications of multilevel linear modeling to study the process by which affect is managed and the
import of this ability to manage emotion as a component of resilience in later life. These studies explore complex interactions between positive affect, negative affect, stress, and resilience mechanisms. Too wide-ranging to be discussed in detail here, the studies have in common the finding that positive and negative affect are distinct phenomena that relate differentially to the experience of stress. There is a relationship between emotional complexity, the ability to distinguish between positive and negative emotion (to the extent that they coexist) and experience of stress: individuals higher in emotional complexity are better able to manage stress (Ong & Bergeman, 2004). On days when positive events outnumber negative, individuals, on average, exhibit more differentiation in and co-occurrence of positive and negative emotional states (Zautra, et al., 2005).

With regard to negative affect in particular, Ong, Bergeman, Bisconti, and Wallace (2006) demonstrated that stress is reliably related to the daily experience of negative affect. Additionally, individuals higher in trait resilience are less reactive to stress-inducing circumstances. The researchers assessed lagged relationships between stress and negative affect, as well as the role that trait resilience played in interindividual differences in these relationships. The results indicated that stress and negative affect had enduring relationships with one another. Specifically, the investigators found a sizable correlation ($\rho=0.42$) between daily negative affect and stress, and observed that trait resilience impacted this relationship. This effect was especially salient for those low in trait resilience, whom, compared to their counterparts higher in trait resilience, both tended to be more reactive to daily stressful life events and had more difficulty regulating their experience of negative emotion.
There appear to be few, if any, empirical studies investigating the role of global or trait-like perceptions of social support in mitigating the relationship between negative affect and stress, but a few studies do speak to the relationship between daily social interaction and well-being (Larson, Mannell, & Zuzanek, 1986; Rook, 2001). Defining well-being solely in terms of positive affect, Larson, et al., (1986) found that interactions with friends, but not with family members, significantly contributed to the daily experience of well-being; older adults appear to find enjoyment and arousal in friendships, which, when available, contributed to substantially greater positive affect. Rook (2001), on the other hand, examined the differential impact of positive and negative social interaction on mood, both positive and negative. The results suggested that positive social exchanges contributed to positive affectivity, but bore little or no relation with negative mood. Hierarchical linear models revealed that negative social exchanges, in contrast, not only damped positive mood, but contributed to higher levels of negative affect. Although these studies represent strong contributions to the literature regarding the impact of social relationships on older adults’ lived experience, neither study accounted for the role stress might play in these relationships.

The theory-method interface as a vehicle for further expanding notions of process.

Returning to the earlier theme that the creative tension between theory and method (Nesselroade, 2006) allows developmental researchers to refine and expand theoretical notions of resilience, dynamical systems analysis (DSA) is another set of important micro-analytic tools that can be employed to capture and describe the role of affectivity in adaptation. One emerging theme in discussions of the theory-method
interface is that despite a resilience-as-process theoretical orientation, many studies of
developmental adaptation nonetheless employ static conceptualizations of change. For
example, proponents of process-oriented research using the classic mediating and
moderating models explicated by Baron and Kenny (1986), test potential mediators and
moderators as variables that might arbitrate a linear relationship between a traditional
regression predictor and outcome. These models posit monotonic increases or decreases
in means over time, with time serving only as an index variable (e.g., stress at Time 1
predicts negative affect at Time 2). Statistical methods that directly incorporate time into
a model of change allow for temporal generality, and are necessary to conclude with
conviction that there exists some process by which one variable consistently impacts
another, independent of the specific time of measurement (e.g., stress predicts negative
affect, not only at Time 2, but at Times 3, 4, etc.; Nesselroade & Schmidt McCollam,
2000). Dynamical systems analysis is one such method, allowing developmentalists to
rise to Nesselroade’s (1990) challenge to move from investigating static
conceptualizations of change to the dynamics of phenomena of interest, to no longer be
satisfied to merely describe developmental change, but, instead, to understand the
process by which it occurs.

From a stress-and-coping point of view, the literature discussed above supports a
general conclusion that human emotion comprises an organized system of affective states
that relate in predictable ways to both stress and the mitigating influences of personal and
social resilience resources. In the same way that developmental psychopathologists
recognize that the information gleaned from studying normal and abnormal development
in tandem is perhaps more revealing than the results of either individual course of study
(Cummings, et al., 2000), it stands to reason that exploring the affective system in both normal and perturbed states could be similarly informative. Bisconti, Bergeman, and Boker (2004), for example, probed the contours of emotional experience by examining the dynamics of emotion regulation in recently bereaved widows. Because conjugal loss is consistently rated to be the most stressful normative life event (Holmes & Rahe, 1967), the researchers’ work may be understood as an investigation of resilience in the affective system when it has been perturbed by a major life event.

The metaphor oft used for emotional experience is that of a rollercoaster (Lund, 1996; Bisconti, et al., 2004), with highs and lows corresponding to the experience of positive and negative emotion (Stroebe & Schut, 2001). These fluctuations over time around a stable equilibrium have been labeled “emotion dynamics” (Thompson, 1990). One way to construe these emotion dynamics is in terms of frequency and damping parameters, which are the components of a damped linear oscillator model. When the damped linear oscillator model is expressed as a differential equation, change, as opposed to the level of a variable at discrete time intervals, is the focus of investigation. The differential equation for a damped linear oscillator model incorporates the speed with which emotional well-being changes (i.e., acceleration) as the dependent variable, which is predicted by both the frequency with which mood fluctuates, as well as the rate at which the perturbed system returns to equilibrium, or damps (Boker & Bisconti, 2006).

Bisconti and colleagues (2004) employed this model to investigate the general course of adjustment across the first three months of adjusting to widowhood (e.g., trend in well-being), as well as intraindividual variability around this trend. From a macroscopic perspective, the researchers found that from the start of the 98-day study to
the end of that time, there was a significant overall positive trend in mood – as time went on, widows experienced increasingly better mental health. The dynamical analysis revealed that there was significant intraindividual variability around this trend, or equilibrium, and that the lability in emotional well-being at the start of the study leveled off, or damped, over time. The authors concluded that as widows adjusted to the deaths of their spouses, they became increasingly better able to manage fluctuations in their moods.

After the process of emotion-regulation was described from a dynamic perspective, the question remained whether any interindividual difference variables reliably predicted the components of the dynamic system. In a follow-up study, the authors reported that aspects of social support predicted interindividual differences both in the overall trend in emotional well-being across time, as well as parameters describing intraindividual variability around that trend (Bisconti, Bergeman, & Boker, 2006). Specifically, emotional support seeking was associated with more pronounced adjustment, or increases in well-being over time, whereas perceived social control was associated with a shallower, less pronounced trend. A similar dichotomous finding was found with regard to parameters describing intraindividual variability, or shorter term fluctuations in mood; the seeking of emotional support was associated with increased damping, whereas instrumental support seeking was associated with well-being returning more slowly to equilibrium.

Using an extension of this methodology, the proposed study investigates the dynamics of affective experience in a typically-stressed, random sample of community dwelling elders. One goal of the study is to understand whether the adaptational processes observed in response to the severe stress of conjugal loss correspond to those used to
cope with more typical daily stressors. Consistent with the call to use methodological advances to test and further develop increasingly process-oriented theoretical notions of human development (Baltes & Nesselroade, 1979; Nesselroade, 2006), the proposed study investigates three salient aspects of developmental change: 1) direct identification of intraindividual change, 2) analysis of interrelationships in behavioral change, and 3) assessment of interindividual differences in intraindividual change.

Direct identification of intraindividual change.

The current research employs a damped linear oscillator model to investigate daily fluctuations in negative affect. The investigation begins at the individual level; individual’s fluctuations around their own preferred emotional states (i.e., equilibria) are captured, and these individual trajectories can then be understood in relation to others’ trajectories. Of particular interest are questions focusing on how individual experience compares to an aggregate picture of emotion dynamics (i.e, mean frequency and damping parameters).

Previous micro-analytic studies suggest that the long-term trajectory of negative affect in older adults is stable (i.e., neither increasing nor decreasing; Carstensen, et al., 2000), but that there is marked, predictable day-to-day variability around that equilibrium (Ong, et al., 2006). Although the proposed study is exploratory in nature, daily negative affect is expected to fluctuate around a stable equilibrium. Whether or not the system will move closer to or farther from its equilibrium over time (i.e., a significant damping/amplification parameter, exhibiting, respectively, either negative or positive values), rather than continually fluctuating around that equilibrium (i.e., a damping
parameter not different from zero), remains an empirical question. Theoretically, given that the emotional system investigated here, in contrast to that explored by Bisconti and colleagues (Bisconti, et al., 2004; Boker & Bisconti, 2006; Bisconti, et al., 2006), is thought to be relatively unperturbed, one might expect no damping or amplification in the system. This expectation is commensurate with the results of an existing study, in which Chow and colleagues (2005) found little significant damping in college students' emotion regulation across a 52-day period (Chow, Ram, Boker, Fujita, & Clore, 2005).

Analysis of interrelationships in behavioral change.

In the investigation of change in negative affect over time, common wisdom suggests that in healthy individuals, emotional lability is probably not an epiphenomenon, but is instead tied to daily life experience. What forces push individuals from their emotional equilibria? Proponents of the stress-and-coping framework would suggest that stress is a necessary, but not sufficient, cause of lability in negative affect. As seen in the studies conducted from the microscopic process perspective, stress plays a large role in emotion dynamics (Ong & Bergeman, 2004; Ong, et al., 2004; Zautra, et al., 2005). Although these studies do not explicitly model coupling between daily fluctuations in affect and daily fluctuations in stress, based upon their results, significant coupling between the systems is expected.

Assessment of interindividual differences in intraindividual change (and in interrelationships in behavioral change).

As noted, stress is not construed as a sufficient cause for lability in negative emotion; instead, a review of the stress-and-coping and resilience literatures suggests that
personal and environmental variables mitigate the effect of stress on emotional experience. Because the focus of the present investigation is resilience in the aging process, personal and community/social support protective factors will be examined for their predictive utility in identifying interindividual differences in intraindividual change in negative affect, and in the coupling of stress to this component of well-being.

The theoretically-specified protective mechanisms are expected to predict interindividual differences in the frequency by which individuals experience shifts in negative affect, although the direction of the effect is difficult to predict. Individuals reporting higher levels of these protective factors may be less affected by situations that might induce negative affect, and thus experience less emotional lability. A rival hypothesis might be that with more resources for managing stress and affect come enhanced ability to move between affective states, such that the experience of greater than equilibrium negative affect is associated with more rapid shifts down toward equilibrium. The latter hypothesis is perhaps less tenable than the first from a resilience perspective because of the associated cost: these individuals would also be expected to move more quickly away from states of lower-than-equilibrium negative affect. Whether or not these mechanisms of protection also predict interindividual differences in damping or amplification over the course of the study will depend, first, on whether or not the time series exhibits those behaviors, thus obviating the possibility of confident a priori prediction.

Furthermore, research hailing from the stress-and-coping framework confirms that resilience mechanisms serve an intermediary role between the stimulus of stress and the affective response. Therefore, interindividual differences in resilience resources are
expected to predict both the strength and hypothesized bidirectional nature of the
coupling of stress and affect such that for individuals reporting greater levels of these
resources, the experience of stress is less associated with negative emotionality, and
negative affect is expected to demonstrate less of an impact on responsivity to stress.

This study represents an empirical investigation growing out of the productive
tension at the interface of method and theory. Dynamical analysis of daily lived
experience of elders not only extends the findings of macroscopic investigations of
resilience in the stress-and-coping process, but speaks, as well, to the role that protective
mechanisms play in the adjustment to the myriad daily stressors of aging.
METHOD

Participants.

Participants comprise a subsample of individuals participating in a study assessing various aspects of the aging process, including measures of stress, personal and community/social support protective factors, and a wide range of psychological and physical health and well-being measures. Initially, participants were asked to send back completed questionnaires assessing broad, trait-like characteristics of interest. Then, if they returned a completed packet and it appeared to have been completed without difficulty, participants were invited to participate in a 56-day daily diary study of their lived experience. Of the 101 people who returned packets, 86 were invited to participate in the daily diary study. Sixty-one (71%) began participation in the daily burst data collection, and of these, 42 (68.8% of participants in the daily sampling; 48.8% of invited participants) met the inclusion criteria for the present study. To be included in the present analyses, participants must have had 75% complete data on the two time series of interest, Negative Affect and Stress (N=44), and complete data on trait measures (N=42). Tests of differences between the 42 individuals with daily data meeting inclusion criteria versus those excluded from the analyses revealed no significant differences with respect to demographics variables or any of the variables included in the study. Overall, tests of differences between individuals participating in the current study

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3 Because the analyses focus on extracting cyclic dynamics in affect and stress, only individuals with relatively large amounts of data were retained for analysis; this choice allows for better reconstruction of the nonlinear dynamics for this subset of the participants, but, admittedly, increases the probability of selection bias.
(N=42) compared to the remainder of the total sample (N=59 of 101) revealed no
significant differences between groups; that is, there appear to be no significant
differences between groups with regard to gender, race, marital status, or living situation
(i.e., alone, with spouse, child, sibling, friend, or other).

Therefore, participants include 42 aging adults ($M_{age} = 78.8$ years; $SD = 6.6$ years;
range: 65-92 years) from in and around a mid-size Midwestern city. Ninety percent of
participants are White, 5% are African-American, and 5% are Hispanic. Eighty-three
percent of the sample is female; 54% live alone and 37% live with a spouse. Ninety-
eight percent of the participants were educated through high school, with 64% of these
attaining some post-high school education. In addition, 24% reported a yearly income
below $15,000; 34% reported an income between $15,000 and $25,000; 24% between
$25,000 and $40,000; and, 17% of the sample reported a yearly income above $40,000.

Measures.

The daily self-report measures of negative affect and stress are described below,
followed by descriptions of the measures assessing trait characteristics hypothesized to
function as protective factors. The daily burst data were collected over 56 days, with one,
two, and three-week packets counterbalanced within and between subjects to circumvent
concerns that the manner in which subjects received and mailed back packets could
contribute to observed periodicity in the data.

The questionnaire measures, also self-report, are described below. To maximize
the available sample, all scales were created using a 20% missing data rule.
Daily Measures.

*Negative Affect.* Daily negative affect was measured using the Negative Affect subscale of the *Positive and Negative Affect Schedule* (PANAS; Watson, Clark, & Tellegen, 1988). Participants were asked to select from a 5-point scale (ranging from 1, “very slightly or not at all,” to 5, “extremely”) the extent to which they had experienced each of the 10 negative affect items. Internal consistency reliability assessed on Day 1 was high (Cronbach’s $\alpha=.90$).

*Stress.* Ten items from the Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983) were modified to assess the degree to which participants experienced daily life as stressful. Items such as, “Today, how often have you felt nervous and ‘stressed’?” and “Today, how often have you felt difficulties were piling up so high that you could not overcome them?” were accompanied by a five point scale (ranging from 0, “never,” to 4, “very often”). Higher scores indicated greater perceived stress. Internal consistency reliability assessed on Day 1 was high (Cronbach’s $\alpha=.89$).

Questionnaire Measures.

*Personal Protective Factors.*

*Dispositional Resilience.* The Dispositional Resilience Scale (DRS; Bartone, Ursano, Wright, & Ingraham; 1989) measures three theoretically-salient personal protective factors: control (i.e., whether one has agency in life, or is instead subject to the whims of powerful others), commitment (i.e, conscientiousness with regard to engaging in and following through on meaningful activities), and challenge, (i.e., characteristically perceives challenges as opportunities for growth rather than as disruptions or threats).
Items such as, “Planning ahead can help me avoid most future problems,” “Trying your best at everything you do really pays off in the end,” and “I like it when things are uncertain and unpredictable” assess each component respectively. Questions were presented individually, with participants being asked to select the answer that most nearly described their feelings (choices range from 1 “not at all true” to 4 “completely true”). Items are reverse scored as necessary such that a higher score indicates a greater amount of dispositional resilience. The scale achieved high internal consistency reliability (Cronbach’s \( \alpha = .88 \)), as well. Although each subscale could be investigated individually, the focus of the present investigation is on the total score, which is a global indicator of personal resources.

**Community/Social Support Factors.**

*Social Support.* The Interview Schedule for Social Interaction (ISSI; Henderson, Duncan-Jones, Byrne, & Scott, 1980) was used to investigate combined quantity and frequency of various supportive behaviors provided by family members, and by friends. Two subscales of the measure were used: amount of support perceived from family, and amount of support perceived from friends. Asked separately for family and friends, questions include, “How many people can you share your innermost feelings with and confide in?,” “How many people in your neighborhood do you know well enough that you can ask them for things?,” and “How many people do you know who can share your joy or who will be happy for you because you feel happy?” Response formats vary across questions, but a typical question has five choices: 1, *nobody*, 2, “1-2,” 3, “3-5,” 4, “6-10,” and 5, “11 or more.” Because response formats differed across questions, items were standardized before scales were created. A higher score indicates a greater amount
of support provided by family and by friends. Internal consistency reliability was acceptable (Cronbach’s $\alpha=.77$; $\alpha=.83$) for the family and friend support scales, respectively.
ANALYSES

Descriptive Statistics.

Descriptive statistics, including means and standard deviations for all variables used in the proposed study are presented in Table 1.

Table 2 contains correlations between time series variables on Day 1 and the proposed resilience resources.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
<th>$\rho_{Age}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA, Day 1</td>
<td>13.58</td>
<td>4.75</td>
<td>10</td>
<td>27</td>
<td>0.25</td>
</tr>
<tr>
<td>Stress, Day 1</td>
<td>11.97</td>
<td>7.2</td>
<td>0</td>
<td>29</td>
<td>0.25</td>
</tr>
<tr>
<td>Disp. Resilience</td>
<td>133.16</td>
<td>13.2</td>
<td>93</td>
<td>164</td>
<td>-0.28</td>
</tr>
<tr>
<td>Friend Support</td>
<td>0.02</td>
<td>4.83</td>
<td>-7.90</td>
<td>11.11</td>
<td>-0.10</td>
</tr>
<tr>
<td>Family Support</td>
<td>0.02</td>
<td>4.49</td>
<td>-8.90</td>
<td>10.4</td>
<td>-0.17</td>
</tr>
</tbody>
</table>

*Note:* N=38-42; no correlations were significant at the $\alpha = .05$ level.
TABLE 2
CORRELATIONS
BETWEEN STUDY VARIABLES

<table>
<thead>
<tr>
<th></th>
<th>NA</th>
<th>Stress</th>
<th>Resilience</th>
<th>Friend</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stress</td>
<td>0.73</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resilience</td>
<td>-0.47</td>
<td>-0.66</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friend</td>
<td>-0.08</td>
<td>-0.37</td>
<td>0.46</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Family</td>
<td>-0.12</td>
<td>-0.47</td>
<td>0.59</td>
<td>0.69</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note: N=38-42; **bold** print indicates a correlation significant at the $\alpha = .05$ level.

Please note that the following description of fitting dynamical systems models is based on descriptions offered by Boker and colleagues (Boker, 2001; Boker & Bisconti, 2006; Bisconti, et al., 2004, 2006).

*Local Linear Approximation.*

The primary objective of the study was to model coupled negative affect and stress time series (i.e., describe those time series in terms of frequency, damping, and coupling parameters), determine whether or not the daily experience of stress is tied to the experience of negative affect on the same day, and to understand whether interindividual differences in selected resilience resources predicted differences between people on parameters describing those time series. To this end, Local Linear Approximation (LLA) was used to fit differential equation models to the data in order to
estimate derivatives; Hierarchical Linear Modeling (HLM) was then used to estimate frequency, damping, and coupling parameters at Level-1, and to predict interindividual differences in those estimates at Level-2.

According to Boker (2001) as cited in Bisconti, Bergeman, and Boker (2004), the initial process of describing a time series in dynamical parameters included three steps:

1. The data were centered around a proposed equilibrium, which in this case is the within-person linear trend across the 56-day study. The residuals from that trend became the first unit of analysis, the intraindividual variability scores.4

2. Local Linear Approximation (LLA) was used to estimate the first and second derivatives (i.e., the change in either affect or stress, and the rate at which that change occurs) for each occasion of measurement. Because derivatives succinctly describe various aspects of change over time, observations must be time lagged by some increment, Tau. In this case, a Tau of 2 was used for every individual.

3. This relationship between reported affective or stress experience and its derivatives is then estimated for each subject.

Direct identification of intraindividual change and analysis of interrelationships in behavior change.

Thus, after the derivatives were estimated, the relationship of daily experienced stress to well-being was explored using a coupled model of stress and negative affect. In this case, dynamical systems analysis allows not only for the investigation of the

---

4 There was a significant linear trend in NA (t(38)Intercept = 23.96; p < 0.001; t(38)Slope = -3.30; p < 0.001); none of the resilience resources predicted interindividual differences in the intercept or slope of this trend.
theoretically salient effect of stress on negative affect, but also facilitates understanding how experience of negative affect may drive the perception of stress. Testing such ideas requires sequentially fitting two Level-1 equations to the data:

\[ (4) \quad \ddot{N}_{it} = \eta_{NAi} N_{it} + \zeta_{NAi} \dot{N}_{it} + \gamma_{NAi} \dot{S}_{it} + e_{NAit} \]

\[ (5) \quad \ddot{S}_{it} = \eta_{Si} S_{it} + \zeta_{Si} \dot{S}_{it} + \gamma_{Si} \dot{N}_{it} + e_{S_{it}} \]

in which \( \ddot{N}_{it} \) is the second derivative (i.e., acceleration) in the measure of affect (NA) for person \( i \) at time \( t \); \( \eta_{NAi} \) (eta) is related to the frequency with which NA for person \( i \) is oscillating around his/her equilibrium; \( N_{it} \) is the NA score for person \( i \) at time \( t \) (i.e., displacement from equilibrium); \( \zeta_{NAi} \) (zeta) is related to the damping or amplification in the system; \( \dot{N}_{it} \) is the first derivative (i.e., velocity) of \( N_{it} \); and \( \gamma_{NAi} \) (gamma) is the coupling parameter, capturing the effect of acceleration of stress (i.e., second derivative: \( \ddot{S}_{it} \)) on the second derivative of negative affect. Also, \( e_{NAit} \) is the error term for person \( i \) at time \( t \). Similarly, \( \ddot{S}_{it} \) is the second derivative (i.e., acceleration) in the measure of stress (S) for person \( i \) at time \( t \); \( \eta_{Si} \) (eta) is related to the frequency with which S for person \( i \) is oscillating around his/her equilibrium; \( S_{it} \) is the S score for person \( i \) at time \( t \) (i.e., displacement from equilibrium); \( \zeta_{Si} \) (zeta) is related to the damping or amplification in the system; \( \dot{S}_{it} \) is the first derivative of \( S_{it} \) (i.e., velocity); and \( \gamma_{Si} \) (gamma) is the coupling parameter capturing the effect of acceleration of negative affect (i.e., second derivative: \( \ddot{N}_{it} \)) on the acceleration of stress. Also, \( e_{S_{it}} \) is error term for person \( i \) at time \( t \). Thus,

\[ 5 \]

It should be noted that, according to Equation 5, acceleration in Stress (\( \ddot{S}_{it} \)) is a function of displacement (\( S_{it} \)) and velocity (\( \dot{S}_{it} \)) in Stress; substituting these terms for \( \ddot{S}_{it} \) into Equation 4 may aid in locating the source of the coupling between the time series: does one component of acceleration, either displacement or velocity, tend to drive acceleration in Negative Affect more than another? If so, how do resilience resources impact these relationships? The appendix examines the results obtained using these expanded equations.
these equations describe individuals’ day-to-day experience of negative affect and stress. The Level-2 analyses, which investigate the extent to which resilience resources predict interindividual differences in frequency, damping (i.e., the tendency for the affective or stress system to return to its equilibrium over time), and coupling between Negative Affect and Stress, allow for a fuller understanding of individual day-to-day experience relative to that of other participants.

Assessment of interindividual differences in intraindividual change (and in interrelationships in behavioral change).

Because the stress-and-coping framework would again posit that a direct effects model of the relationship between stress and affect is incomplete, theoretically-important resilience resources were examined in their effects on the relationship between negative affect and stress. Factors associated with an attenuation of the effect of stress on affect would be considered protective in this context. The selected personal and social protective factors were examined in the extent to which they reliably predicted interindividual differences in the frequency, damping, and coupling parameters between the time series using the following Level-2 equations:

\[(6) \eta_{NAi} = \beta_{NA0} + \beta_{NA1} DR_i + \beta_{NA2} FR_i + \beta_{NA3} FM_i + w_{NAi}\]

\[(7) \zeta_{NAi} = \beta_{NA0} + \beta_{NA1} DR_i + \beta_{NA2} FR_i + \beta_{NA3} FM_i + w_{NAi}\]

\[(8) \gamma_{NAi} = \beta_{NA0} + \beta_{NA1} DR_i + \beta_{NA2} FR_i + \beta_{NA3} FM_i + w_{NAi}\]

\[(9) \eta_{Si} = \beta_{S0} + \beta_{S1} DR_i + \beta_{S2} FR_i + \beta_{S3} FM_i + w_{Si}\]

\[(10) \zeta_{Si} = \beta_{S0} + \beta_{S1} DR_i + \beta_{S2} FR_i + \beta_{S3} FM_i + w_{Si}\]

\[(11) \gamma_{Si} = \beta_{S0} + \beta_{S1} DR_i + \beta_{S2} FR_i + \beta_{S3} FM_i + w_{Si}\]
in which $\eta_{NAi}$ is the frequency parameter of the negative affect trajectory for person $i$, $\zeta_{NAi}$ is the parameter describing damping in negative affect for person $i$, $\gamma_{NAi}$ is the coupling of stress to negative affect for person $i$; $\beta_{NA\eta0}$, $\beta_{NA\zeta0}$, and $\beta_{NA\gamma0}$ are the mean values of $\eta$, $\zeta$, and $\gamma$, respectively, for negative affect; $DR_i$, $FR_i$, $FM_i$ are, respectively, dispositional resilience, quantity of friend support, and quantity of family support at the start of the study for person $i$ as explored in predicting trajectory parameters, and $w_{NA\eta i}$, $w_{NA\zeta i}$, and $w_{NA\gamma i}$ are unique error terms. Similarly, $\eta_{Si}$ is the frequency parameter of the stress trajectory for person $i$, $\zeta_{Si}$ is the parameter describing damping in stress for person $i$, $\gamma_{Si}$ is the coupling of negative affect to stress for person $i$; $\beta_{S\eta0}$, $\beta_{S\zeta0}$, and $\beta_{S\gamma0}$ are the mean values of $\eta$, $\zeta$, and $\gamma$, respectively, for stress; $DR_i$, $FR_i$, $FM_i$ are, respectively, dispositional resilience, quantity of friend support, and quantity of family support at the start of the study for person $i$ as explored in predicting trajectory parameters, and $w_{S\eta i}$, $w_{S\zeta i}$, and $w_{S\gamma i}$ are unique error terms.
RESULTS

Table 3 contains the results of the analyses of primary interest, which describes the daily experience of negative affect in terms of frequency, damping, and coupling with stress. The significant \( \eta \) parameter \((t_{(38)} = -33.52; p<0.001)\) indicates that the frequency by which negative affect is fluctuating around its equilibrium is significantly different than zero. The nearly significant negative \( \zeta \) parameter \((t_{(38)} = -2.00; p=0.05)\) describes damping in the system; in other words, with time, individuals’ negative affect systems are moving closer to their stable equilibria. Especially interesting is that \( \gamma \), the parameter approximating coupling of Stress to the Negative Affect time series, is significant \((t_{(38)}= 6.15; p<0.001)\), with acceleration in Stress significantly predicting acceleration in Negative Affect.

With regard to the Level-2 models, of the three resilience resources, Dispositional Resilience, Friend Support, or Family Support, only Family Support \((t_{(38)}=-2.25; p=0.03)\) demonstrated predictive utility with regard to interindividual differences in \( \eta \); the negative relationship suggest that reporting more of this resource is associated with a faster frequency such that faster shifts from equilibrium are accompanied by faster regaining of equilibrium.
TABLE 3:

PARAMETERS OF CHANGE IN NEGATIVE AFFECT
AND PREDICTORS OF INTERINDIVIDUAL DIFFERENCES
IN FREQUENCY, DAMPING, AND COUPLING IN MODELED FLUCTUATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient</th>
<th>SE</th>
<th>(t_{(38)})</th>
<th>(p)-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eta (Frequency; Reliability = 0.44)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eta Mean</td>
<td>0.4169</td>
<td>0.0124</td>
<td>-33.52</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Disp. Resilience</td>
<td>-0.0009</td>
<td>0.0010</td>
<td>-0.98</td>
<td>0.33</td>
</tr>
<tr>
<td>Friend Support</td>
<td>0.0002</td>
<td>0.0036</td>
<td>0.06</td>
<td>0.95</td>
</tr>
<tr>
<td>Family Support</td>
<td>-0.0077</td>
<td>0.0034</td>
<td>-2.25</td>
<td>0.03</td>
</tr>
<tr>
<td>Zeta (Damping; Reliability = 0.38)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zeta Mean</td>
<td>0.0696</td>
<td>0.0347</td>
<td>2.00</td>
<td>0.05</td>
</tr>
<tr>
<td>Disp. Resilience</td>
<td>-0.0032</td>
<td>0.0015</td>
<td>-2.09</td>
<td>0.04</td>
</tr>
<tr>
<td>Friend Support</td>
<td>0.0130</td>
<td>0.0071</td>
<td>1.83</td>
<td>0.07</td>
</tr>
<tr>
<td>Family Support</td>
<td>-0.0112</td>
<td>0.0105</td>
<td>-1.07</td>
<td>0.29</td>
</tr>
<tr>
<td>Gamma (Coupling; Reliability = 0.73)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gamma Mean</td>
<td>0.1433</td>
<td>0.0233</td>
<td>6.15</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Disp. Resilience</td>
<td>-0.0032</td>
<td>0.0018</td>
<td>-1.76</td>
<td>0.09</td>
</tr>
<tr>
<td>Friend Support</td>
<td>0.0093</td>
<td>0.0057</td>
<td>1.65</td>
<td>0.11</td>
</tr>
<tr>
<td>Family Support</td>
<td>-0.0086</td>
<td>0.0038</td>
<td>-2.28</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Note: Disp. Resilience = Dispositional Resilience.

Dispositional Resilience and Friend Support both predicted interindividual differences in the extent to which the affective system moved closer to its equilibrium over time. Interestingly, the relationship between the damping parameter and Dispositional Resilience was negative \(t_{(38)} = -2.09; p = 0.04\), which indicates that the time series of hardier people exhibit greater damping; the positive relationship between Friend
Support and the damping parameter \((t_{38} = 1.83; p = 0.07)\) tends toward significance, and indicates that the time series of individuals reporting greater amounts of support from friends exhibit less damping. The relationship was non-significant for Family Support \((t_{38} = -1.07; p = 0.29)\).

The negative trend toward significance of the relationship between dispositional resilience and interindividual differences in this coupling parameter suggests that for hardier individuals, the experience of negative affect may be less tied to (or more independent of) the experience of stress \((t_{38} = -1.76; p = 0.09)\). The relationship holds for Family Support, as well \((t_{38} = -2.28; p = 0.03)\). Whether this relationship is significant for Friend Support is not clear in the present analysis \((t_{38} = 1.65; p = 0.11)\).

Finally, although the negative affect trajectory is of primary interest, the last series of models help identify reciprocal relationships between negative affect and stress; the coupling parameter, \(gamma\), represents the impact that acceleration in negative affect has on the behavior of the daily stress system. As the results in Table 4 indicate, stress behaves somewhat differently than negative affect in that there appears to be perturbations in the systems occurring at a non-zero frequency \(\eta \approx 29.57; p < 0.001\), but whether the system is damping toward some stable equilibrium is not clear \((\zeta; t_{38} = -1.53; p = 0.13)\). There is, however, significant coupling between the systems \(gamma\) such that acceleration in negative affect is predictive of acceleration in Stress \((t_{38} = 8.13; p < 0.001)\). Interestingly, none of the resilience resources investigated here – Dispositional Resilience, Friend Support, or Family Support – predict interindividual differences in any of the parameters of interest (i.e., frequency, damping, and coupling in the Stress time series).
TABLE 4:
PARAMETERS OF CHANGE IN STRESS
AND PREDICTORS OF INTERINDIVIDUAL DIFFERENCES
IN FREQUENCY, DAMPING, AND COUPLING IN MODELED FLUCTUATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient</th>
<th>SE</th>
<th>$t_{(38)}$</th>
<th>$p$-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eta (Frequency; Reliability = 0.63)</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Eta Mean</td>
<td>-0.4260</td>
<td>0.0106</td>
<td>-29.57</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Disp. Resilience</td>
<td>-0.0022</td>
<td>0.0011</td>
<td>-1.48</td>
<td>0.15</td>
</tr>
<tr>
<td>Friend Support</td>
<td>0.0006</td>
<td>0.0028</td>
<td>0.17</td>
<td>0.86</td>
</tr>
<tr>
<td>Family Support</td>
<td>0.0071</td>
<td>0.0026</td>
<td>1.56</td>
<td>0.13</td>
</tr>
<tr>
<td><strong>Zeta (Damping; Reliability = 0.03)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zeta Mean</td>
<td>-0.0163</td>
<td>0.0106</td>
<td>-1.53</td>
<td>0.13</td>
</tr>
<tr>
<td>Disp. Resilience</td>
<td>-0.0007</td>
<td>0.0011</td>
<td>-0.68</td>
<td>0.50</td>
</tr>
<tr>
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<td>0.0028</td>
<td>-0.13</td>
<td>0.90</td>
</tr>
<tr>
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<td>0.0026</td>
<td>0.87</td>
<td>0.38</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
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<tr>
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<td>0.0098</td>
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</table>

Note: Disp. Resilience = Dispositional Resilience.
DISCUSSION

Overall, patterned variability in daily negative affect was detected such that individuals’ perturbations from their emotional equilibria occurred at a non-zero frequency, damped toward that equilibrium over time, and were significantly related to the concurrent daily experience of stress. In addition, the observed reciprocal influences between negative affect and stress suggested that acceleration in stress not only predicted acceleration in negative affect, but also the reverse, that acceleration in negative affect exacerbates stress, supporting the original hypothesis concerning these relationships.

Direct identification of intraindividual change.

In the context of the current model, in which negative affect is construed as a damped linear oscillator to which acceleration in stress has been coupled, negative affect appears to fluctuate around a stable equilibrium during a 56-day snapshot of elders’ typical lives. Although there appears to be no extant literature to directly corroborate this finding, similar emotion dynamics have been observed in college students (Chow, et al., 2005) and in older widows recovering from conjugal loss (Bisconti, et al., 2004). Although not statistically significant at the $\alpha<0.05$ level (see below for a discussion of statistical power), the system appeared to be damping toward its equilibrium over time. Again, because the current analysis is based on data gathered as a 56-day “snapshot” of older people’s lives, and that the snapshots are believed to be random in that individuals are not aligned on any one stressor, the time series was not expected to damp toward its
equilibrium over time. Although this coefficient is small ($\zeta_{\text{NAI}} = -0.07$), it is reliably predicted by resilience resources (considered below), and should not be ignored. Because this study appears to be among the first to investigate the course of daily negative affect in this manner, replication is warranted.

With regard to overall description of the Level-1 time series, Stress behaved similarly to Negative Affect. In this model, in which stress is construed as a damped linear oscillator to which acceleration in negative affect has been coupled, the original hypothesis that an individual’s daily experience of stress would fluctuate around a stable equilibrium was confirmed. In addition, although the time series was not expected to damp toward its equilibrium over time, the damping parameter (i.e., $\zeta$) tended toward significance. The associated coefficient was very small ($\zeta_{\text{NAI}} = -0.02$), however, and is not related to any of the interindividual difference variables currently investigated. In a study employing a similar model (Chow, et al., 2005), the investigators chose not to interpret a damping parameter of this magnitude, and suggested that the parameter was not practically, as opposed to statistically, significantly different from zero. Therefore, the current findings invite replication with additional data obtained from older adults to understand whether, over time, elder adults’ experiences of stress tends to damp toward their equilibria.

Analysis of interrelationships in behavioral change.

Although description of the stress and negative affective experiences from a dynamical systems perspective are interesting in their own right, especially intriguing are the final parameters in the each model, the coupling parameters (i.e., $\gamma$s) which
describe reciprocal influences between the systems. These parameters describe how acceleration in one variable relates to acceleration in the other. There appears to be mutual coupling between the systems such that acceleration in stress significantly predicts acceleration in negative affect, and acceleration in negative affect reliably impacts acceleration in stress. This significant coupling affirms the hypothesized relationship between the stress and affective systems, and supports extant results in the stress literature. Although the previous work did not explicitly model coupling between the systems, these studies all found relationships between stress and negative affect (Ong & Bergeman, 2004; Ong, et al., 2004; Zautra, et al., 2005).

Assessment of interindividual differences in intraindividual change and in interrelationships in behavioral change.

Perhaps more interesting than the description of these systems is the extent to which their parameters are predictable by resilience resources. Although the effects of the resilience resources are not universal with respect to the aspect of change in the affect system to which they relate, some overall interesting effects emerge. Please note that many of the effects interpreted here did not meet the $p<0.05$ criterion for statistical significance (instead, $\alpha_{critical} = 0.10$), although, with a larger sample or a more powerful analysis (see below for a discussion of statistical power), it is expected that these will achieve statistical significance. Please note, as well, that there was no significant prediction of frequency, damping, and coupling parameters in the analyses involving the Stress time series; because of the acknowledged concerns with statistical power and the fact that null results must be interpreted with extreme caution, these results will not be discussed.
With respect to \( \eta \) (i.e., the frequency parameter), only Family Support predicted interindividual differences in the frequency of change in negative affect. Although a negative relationship was originally hypothesized to be less tenable from a resilience perspective because being quicker to return to equilibrium once the affective system was perturbed from it comes with the associated cost of moving more quickly from equilibrium once perturbed, a conceptually similar process is described in the literature. Using Ego Resilience (Block & Kremen, 1996) as the independent variable, Ong and colleagues (2006) found that more highly resilient individuals used positive emotions to resolve negative affective feelings induced by stress, which corroborates the interpretation that resilient functioning involves more rapid shifts between mood states. The authors (2006, p. 745) highlight the need for dynamical systems research to test the “fundamental assumption underlying the process of resilience… that resilient functioning is characterized by quicker return to equilibrium (Curtis & Cicchetti, 2003; Davidson, 2000);” the finding for Family Support as one such resilience resource supports such a claim.

Although the significance of the damping parameter (i.e, \( zeta \)) is difficult to interpret because damping was not expected in the system, the literature suggests that maintaining or returning to an equilibrium mood state (i.e., damping) is adaptive (Bisconti, et al., 2004; 2006; Curtis & Cicchetti, 2003; Davidson, 2000; Ong, et al., 2006). Thus, resilience resources should be associated negatively with damping (i.e, \( zeta \)), indicating that higher levels of resilience resources should be associated with a greater tendency for Negative Affect to return to equilibrium when the affective system is perturbed. Although Family Support did not predict interindividual differences in
damping (i.e., $\zeta$), both Dispositional Resilience and Friend Support did. Dispositional Resilience was associated with $\zeta$ in the expected direction – greater levels of hardiness were associated with more damping toward equilibrium.

Surprisingly, greater Friend Support was associated with less damping in Negative Affect. Although it is difficult to interpret this finding, especially from a resilience perspective, the consistency of the finding across analyses suggests that a theoretically important process may be occurring that requires replication in the service of explication. The observed relationship, however, could also be artifactual. First, it has been suggested that social support, as a construct, is often too broadly construed and may be “not simply as cause (of disorder) or buffer (of stress) but also a consequence and correlate of, and sometimes surrogate for, measures of these related constructs” (Monroe & Steiner, 1986, p. 29). If the Friend Support measure is tapping into relational stress, as well as in to quantity of supportive individuals in the friend network, one would expect higher levels of this variable to be associated with less adaptive functioning. One is hard pressed, however, without further investigation, to explain why Family Support, when it relates to variables of interest, is relating in expected directions. Relatedly, these unexpected results could be indicative of something akin to the intervention selection bias. Selection biases are an especially pernicious instantiation of the third-variable problem whereby interventions (loosely defined, in this case, as greater activation of the friend support network) appear to be harmful when, in fact, outcome differences reflect pre-existing differences in the people being compared (Lazarelle, Kuhn, & Johnson, 2004). Related to the potential overlap between social support and stress, then, it could be that individuals who tend to adapt to stress less well (at great cost in terms of negative
affect) are using (and, thus, reporting) more friend support such that increased values of
social support appear to be associated with poorer functioning, when, in fact, the results
are driven by the fact that these individuals were coping more poorly in the first place.
Additional research is planned to determine whether the current finding is of theoretical
and practical importance, or the artifact of a form of selection bias.

From a resilience perspective within the stress-and-coping framework, predictors
of interindividual differences in the coupling parameter, $\gamma$, are especially
interesting. If, as in the aging literature, resilience is construed as the maintenance of
health and well-being despite the numerous stressors that accompany advancing years
(Bergeman & Wallace, 1999), it would seem that resilience-as-process could be
operationalized as the extent to which an elder experiences acceleration in stress but does
not pay an emotional cost in terms of acceleration in negative affect. That is, individuals
for whom the experience of stress is relatively independent of the experience of negative
affect would be considered more resilient than those for whom the experiences are
closely tied. Thus, from a resilience perspective, arguably, the most interesting results of
the current set of analyses concern interindividual differences in coupling between
negative affect and stress. This process of resilience, then, is observed most clearly in the
Level-2 models in which interindividual differences in $\gamma$ are predicted by resilience
resources. The negative relationship observed between Dispositional Resilience and the
coupling parameter suggests that for hardier individuals, acceleration of stress is less tied
to acceleration in negative affect. This relationship holds for the Family Support, as well
– a greater amount of perceived support from family is associated with decreased
coupling of stress to negative affect. The relationship between Friend Support and
gamma was positive and tending toward significance, although it failed to meet the revised criterion for significance ($\alpha_{\text{critical}} = 0.10$). Nonetheless, the concerns highlighted above with respect to Friend Support and its relationship to investigated parameters hold here, as well. Overall, however, it seems that resilience resources reliably predict interindividual differences in the extent to which the daily experiences of stress and negative affect are tied together. These trait-like characteristics foster resilient functioning not only to the extent to which they help individuals manage affect (in terms of frequency and damping of negative emotion), but also to the extent that they interrupt the coupling between the experience of stress and resultant affect.

Thus, it seems that, in response to the central substantive question guiding this dissertation project, there is evidence to suggest that resilience is both a trait and a process.

*Strengths, limitations, and future directions: Methodological considerations and concern regarding statistical power.*

As noted above, the use of dynamical systems analysis is a particular strength of this study. At the forefront of the theory-method interface, the availability of this technique challenges researchers to move beyond static conceptualizations of change to entertain the notion that affective experience is an evolving psychological process, with predictable parameters of change. Results suggest that, as the stress-and-coping framework postulates, stress impacts the experience of aspects of well-being; an important strength of the current methodology is that dynamical systems allows for identification of the reciprocal influences of negative affect on responsivity to stress, as well.
With regard to the methods used in this particular series of analyses, some discussion is warranted. An initial, crucial step in the dynamical analysis is to choose a \textit{Tau}, the value by which observations are time-lagged to estimate derivatives, which succinctly describe various aspects of change over time. It has been shown that when using Local Linear Approximation (LLA), \textit{Tau} is related to estimates of \textit{eta}, the frequency parameter (Boker & Laurenceau, 2006; Boker & Nesselroade, 2002). In this case, a \textit{Tau} of 2 was used for every individual. Because the selection of a single \textit{Tau} has the potential to greatly reduce interindividual variability in frequency, follow-up analyses may allow for individual-specific \textit{Taus}, thereby increasing the likelihood that extant relationships between frequency of change and the resilience resources impacting it can be teased apart.

In addition, with regard to more general methodological concerns, the current analyses employ LLA, in which coupled models must be estimated sequentially rather than simultaneously. It could be that when the differential equations are solved simultaneously, one time series may be observed to exert more of an influence on the other, altering the estimated coupling parameters. Thus, follow-up analyses will be conducted using Latent Differential Equations (LDE; Boker, Neale, & Rausch, 2004), an estimation method allowing for the simultaneous estimation of coupled oscillating systems, to help tease apart the relative directionality of these effects (i.e., whether stress tends to drive negative affect, negative affect colors the experience of stress, or they exert equal reciprocal force on one another).

Another important strength of LDE is that, in contrast to LLA, the former method allows for estimation of derivatives and relationships between them at the latent level.
These latent relationships are, by definition, not attenuated by measurement error (McDonald, 1999), and thus models based on LDE are more powerful than those based on LLA, which estimates derivatives and their accompanying interrelationships at the manifest level. Because statistical power rests on both sample size and effect size (Maxwell & Delaney, 2000), the results of the current analyses using LLA could be located closer to the lower bound of the confidence intervals around the true relationships in the broader population. Thus, null results must be interpreted with extreme caution; it is therefore acknowledged that some license has been taken with regard to interpreting parameters that tend toward, but do not actually achieve, statistical significance ($p < 0.10$).

Furthermore, the current study investigates concurrent relationships between the daily experience of stress and the daily affect experience. Previous research, however, suggests that stress and negative affect may have enduring, lagged relationships with one another; Ong and colleagues (2006) found that stress impacted negative affect as many as three days out. Future analyses could explore lagged relationships between coupled systems, explicating how long these coupled relationships endure and whether resilience resources attenuate the duration of the reciprocal influences.

Returning to the notion of protective factors, one of the most compelling themes in the literature is that the resilience resources on which people draw may undergo positive and negative changes themselves (Pearlin & Skaff, 1995). Although the current study, in taking a finer-grained approach to investigating adaptive functioning in the context of stress, represents a strong contribution to the understanding of the coupled experience of stress and affect in the elderly, as well as of the resilience resources associated with interindividual differences in this process, the study nonetheless relies on
broad, trait-like conceptualizations of these protective mechanisms. Future research might explore whether or not there is reliable change in the perceptions of these resources, and what relationship, if any, these fluctuations have on the dynamic relationships explored in the present study. Data is currently being collected to investigate this possibility.

Interestingly, although the use of self-report measures could be considered a limitation, it may, instead, be construed as a strength of this study of negative affect. Because people “evaluate conditions based on their unique expectations, values, and previous experiences,” they react differently to ostensibly congruent circumstances (Diener, Suh, Lucas, & Smith, 1999, p. 277). Therefore, perceptions of situations may be more indicative of an individual’s experience than more objective reports, and thus more reliably associated with other variables of interest.

Contributions.

The current study represents a strong contribution to the resilience literature in a number of ways. First, the study joins other micro-analytic studies in the attempt to extend the vast literature on adaptation to life stress; informed by the results of long-term change in subjective well-being, the study speaks to whether the process of resilience explicated by macroscopically-oriented studies corresponds to the lived experience of older adults. Secondly, the study employs a dynamic conception of change, and investigates the extent to which theoretically-chosen resilience mechanisms mitigate reciprocal relationships between life stress and negative affect. Guided by the first three of Baltes and Nesselroade’s (1979) five identified rationale for longitudinal investigation
of developmental phenomena, the study systematically engages developments at the theory-method interface to refine understanding of older adults’ adaptation to ordinary life stress and the process by which it occurs. In the end, the results inform the theoretical literature concerning the nature of resilience, and indicate that this adaptive capacity is both a trait and a process.
REFERENCES


Further analysis of interrelationships in behavior change, and predictors of interindividual differences in interrelationships in behavior change.

The first series of analyses revealed significant coupling between negative affect and stress such that acceleration in Stress significantly predicted acceleration in NA; all three resilience resources tended to predict interindividual differences in this coupling, although only Dispositional Resilience and Family Support met the revised criterion for significance ($\alpha_{\text{critical}} = 0.10$). From a process perspective, the question becomes: since, according to Equation 5, acceleration in Stress ($\ddot{S}_i$) is a function of displacement ($S_i$) and velocity ($\dot{S}_i$) in Stress, where does the coupling between the time series occur? Furthermore, can more closely examining the nature of the coupling yield more information with regard to how in and in what way resilience resources impact the coupling between Negative Affect and Stress? Testing these ideas requires fitting an expanded Level-1 equation to the data:

$$\ddot{N}_{it} = \eta_{\text{NA}i} N_{it} + \zeta_{\text{NA}i} \dot{N}_{it} + \eta_{\text{SNA}i} S_{it} + \zeta_{\text{SNA}i} \dot{S}_{it} + e_{\text{NA}it}$$

in which $\ddot{N}_{it}$ is the second derivative in the measure of affect (NA) for person $i$ at time $t$; $\eta_{\text{NA}i}$ (eta) is related to the frequency with which NA for person $i$ is oscillating around his/her equilibrium; $N_{it}$ is the NA score for person $i$ at time $t$; $\zeta_{\text{NA}i}$ (zeta) is related to the damping or amplification in the system; $\dot{N}_{it}$ is the first derivative of $N_{it}$. Also, $\eta_{\text{SNA}i}$ is the coupling parameter capturing the effect of displacement of stress (i.e., $S_{it}$) on the second derivative of negative affect; $\zeta_{\text{SNA}i} \dot{S}_{it}$ is the coupling parameter capturing the effect of
velocity of stress (i.e., $\dot{S}_i$) on the second derivative of negative affect. Lastly, $e_{NAi}$ is the error term for person $i$ at time $t$.

The selected personal and social protective factors were then examined in the extent to which they reliably predicted interindividual differences in the frequency, damping, and additional coupling parameters of Stress to the Negative Affect time series using the following Level-2 equations:

$$\begin{align*}
\text{(A.2)} & \quad \eta_{NAi} = \beta_{NA0} + \beta_{NA1} DR_i + \beta_{NA2} FR_i + \beta_{NA3} FM_i + w_{NAi} \\
\text{(A.3)} & \quad \zeta_{NAi} = \beta_{NA0} + \beta_{NA1} DR_i + \beta_{NA2} FR_i + \beta_{NA3} FM_i + w_{NAi} \\
\text{(A.4)} & \quad \eta_{SNAi} = \beta_{SNA0} + \beta_{SNA1} DR_i + \beta_{SNA2} FR_i + \beta_{SNA3} FM_i + w_{SNAi} \\
\text{(A.5)} & \quad \zeta_{SNAi} = \beta_{SNA0} + \beta_{SNA1} DR_i + \beta_{SNA2} FR_i + \beta_{SNA3} FM_i + w_{SNAi}
\end{align*}$$

in which $\eta_{NAi}$ is the frequency parameter of the negative affect trajectory for person $i$, $\zeta_{NAi}$ is the parameter describing damping in negative affect for person $i$, $\gamma_{NAi}$ is the coupling of stress to negative affect for person $i$, $\beta_{NA0}$, $\beta_{NA1}$, $\beta_{SNA0}$, and $\beta_{SNA0}$ are the mean values of $\eta$, $\zeta$, $\eta_{SNA}$ and $\zeta_{SNA}$, respectively; $DR_i$, $FR_i$, $FM_i$ are, respectively, dispositional resilience, quantity of friend support, and quantity of family support at the start of the study for person $i$ as explored in predicting trajectory parameters, and $w_{NAi}$, $w_{NAi}$, $w_{SNAi}$, and $w_{SNAi}$ are unique error terms.

The results of these analyses can be found in Table A.1. Of interest are the additional coupling parameters describing the effect of stress on the experience of negative affect.\textsuperscript{6} Although the intercept of the $Eta_{SNA}$ term, which describes the extent to which, across individuals, displacement on $S$ significantly predicts acceleration in NA,

\textsuperscript{6} Because there were no significant parameters relating to the association between velocity of Stress and acceleration in Negative Affect, these results will not be discussed.
TABLE A.1:
PARAMETERS OF CHANGE IN NEGATIVE AFFECT
AND PREDICTORS OF INTERINDIVIDUAL DIFFERENCES
IN FREQUENCY, DAMPING, AND MORE FULLY ELABORATED COUPLING IN
MODELED FLUCTUATIONS

<table>
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<tr>
<th>Parameter</th>
<th>Coefficient</th>
<th>SE</th>
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<th>p-Value</th>
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</thead>
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<tr>
<td>Eta (Frequency; Reliability = 0.25)</td>
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<tr>
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<td>0.0009</td>
<td>-1.15</td>
<td>0.26</td>
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<tr>
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<td>0.0036</td>
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<td>0.0038</td>
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<tr>
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</table>

Note: Disp. Resilience = Dispositional Resilience.
was non-significant ($t_{(38)}= -0.99; p= 0.33$), interindividual differences in this form of coupling are predictable by both Friend Support ($t_{(38)}= -3.52; p< 0.001$) and Family Support ($t_{(38)}= 3.76; p< 0.001$); especially interesting is the opposite sign of these effects. The negative relationship between Friend Support and displacement from equilibrium in Stress suggests that for individuals reporting more Friend Support, greater displacement in Stress is associated with greater acceleration in Negative Affect. The more perturbed from equilibrium individuals’ stress systems are, the greater the tendency for their affective systems to move more quickly (i.e., accelerate) back toward equilibrium. Therefore, one interpretation would be that for individuals reporting greater amounts of support from friends, the experiences of negative affect and stress are more closely linked than for those lower in Friend Support; Stress impacts NA such that increased feelings of stress (i.e, increased displacement) may elicit regulation in affect (i.e., greater acceleration toward equilibrium). Similarly, the positive coefficient associated with Family Support indicates that people reporting greater amounts of support from family exhibit less acceleration in NA in relation to displacement in Stress. Presumably, the experience of NA is more independent of the experience of Stress for these individuals; disregulation in Stress (i.e., being displaced from equilibrium) is associated with less acceleration in NA for those reporting more Family Support relative to individuals reporting less. Thus, although replication is clearly warranted to understand whether the opposite direction of effects between Friend Support and Family Support are a theoretically compelling finding, or artifactual in nature, it appears that the significant coupling between acceleration in Stress and acceleration in Negative Affect is largely a function of displacement on Stress.