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# New daters' acute physiological responses to a standardized stressor: Do nonadaptive hormone responses forecast romantic breakups?

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# New daters' acute physiological responses to a standardized stressor: Do nonadaptive hormone responses forecast romantic breakups?

by

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## Abstract

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The quality and longevity of any romantic relationship depends in large part on the manner in which individuals respond to stressful situations (Karney & Bradbury, 1995). Research on the link between stress and relationship outcomes has focused almost exclusively on marital relationships. With this in mind, the current study explored associations between general stress responses (i.e., reactivity and recovery) to a psychosocial stressor and nonmarital breakup status. Data were collected as part of a larger 9-month longitudinal study investigating the mental and physical health outcomes associated with relationship transitions (e.g., breakups). Participants underwent a standardized stress protocol (i.e., The Trier Social Stress Test; Kirschbaum, Pirke, & Hellhammer, 1993) that incorporates motivated performance tasks, uncontrollability, and social-evaluative threat—all of which are key components to reliably eliciting a stress response (Dickerson & Kemeny, 2004). Physiological reactivity and recovery were assessed using samples of salivary cortisol, a stress hormone of the hypothalamic-pituitary-adrenal (HPA) axis—one of the body's primary stress response systems. Results from multilevel modeling indicated that cortisol trajectories among those whose relationships persisted versus those whose relationships ended were not significantly different from one another. Additionally, individuals who displayed nonadaptive hormone responses to a novel setting and a standardized stressor (i.e., took longer to recover, demonstrated greater increases in total cortisol output) were no more likely to report experiencing a breakup than were individuals who displayed adaptive responses to the same settings. Findings are discussed with regard to identifying factors that may be related to patterns of physiological function and nonmarital relationship outcomes.

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# INTRODUCTION

The quality and longevity of any romantic relationship depends in large part on the manner in which individuals respond to stressful situations (Karney & Bradbury, 1995). Whether it be coordinating dinner with a partner after a hard day's work, or resisting the urge to react negatively when a partner offers constructive criticism, the extent to which partners respond to stress forecasts the overall well-being of their romantic relationships (Kiecolt-Glaser, Bane, Glaser, & Malarkey, 2003). However, to claim that stress has a corrosive effect on individuals' *relationships* is perhaps too broad a claim; the vast majority of extant research on this topic has focused on *marital unions*. Much less is known about the degree to which stress responses predict *nonmarital functioning and outcomes*. Moreover, although research on 'stress spillover' implies that individuals' ability to manage stress, in general, has important implications for relationship well-being, to date there is limited work directly testing whether individuals' physiological responses to general stress predict subsequent relationship outcomes. To fill these gaps, the current study tests whether acute stress reactivity and recovery to a standardized speech and math task predict subsequent relationship status (i.e., together vs. not) in a sample of newly-dating individuals.

Below, I briefly review how stress has been defined in the literature and explain how the body responds to stress. I next discuss the lasting and detrimental effects that stress has on individual and relationship well-being. In the final section I explain why general stress responses may predict dating relationship outcomes.

## STRESS AND STRESS RESPONSES

The term stress is used to refer to a wide range of experiential states, both psychological and physiological in nature, resulting from situations in which individuals are faced with a changing environment. Selye, who coined the term "stress", defined stress as "a nonspecific response of the body to any demand placed upon it" (i.e., the stress response; Selye, 1978b, p.74). Subsequently, a number of slightly different conceptualizations and modifications of this construct and definition have been offered. Some researchers have placed the emphasis on the psychological components of stress; for example, Lazarus and Folkman (1984) define stress as "a relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being" (p. 21). Other researchers have focused on the physical concomitants of stress, such as Chrousos and Gold (1992) who define stress as "a state of disharmony, or threatened homeostasis" resulting from internal and external forces (i.e., stressors). And still others define stress as the interplay between psychological and physiological processes, whereby emotions, cognitions, and physical experiences reciprocally influence one another in order to produce psychophysiological stress responses (Blascovich & Mendes, 2000). Regardless of how stress is defined, a general distillation of the literature suggests that stress is used to refer to any change in our normal physiology or psychological state that is brought on by a need to adapt to changing environmental conditions. Consequently, stress occurs when an individual is exposed to a "stressor"—or any demand that provokes a stress response.

The experience of a stressor activates the hypothalamic-pituitary-adrenal (HPA) axis—a series of physiological responses and adaptations that aim to maintain internal stability and to return the body's physiological conditions back to normal (homeostasis; Dickerson & Kemeny, 2004). This physiological process includes activation of the hypothalamus, which in turn prompts the pituitary gland to send signals to the adrenal gland to release cortisol—one of the body's primary stress hormones (for review, see Lovallo & Thomas, 2000). Cortisol plays a vital role in maintaining homeostasis by increasing glucose in the bloodstream and supplying an immediate energy source that enables individuals to manage the stressor at hand. Cortisol is also responsible for shutting off the HPA axis once the stressor terminates or is no longer perceived as stressful.

Indeed, short-term activation of the HPA axis is adaptive (Charmandari, Tsigos, Chrousos, 2005; Kyrou & Tigos, 2009). *Adaptive* responses are characterized by increased levels of cortisol after the onset of a stressor, followed by a relatively rapid return to baseline. Failure to respond adaptively is characterized by increased cortisol levels following the onset of a stressor and a longer delay in returning to baseline (Gunnar, Wewerka, Frenn, Long, & Griggs, 2009; Klimes-Dougan, Hastings, Granger, Usher, & Zahn-Waxler, 2001). These responses are considered *nonadaptive* and are implicated in many stress-related disorders (e.g., metabolic risk, depression, anxiety; McEwen, 2012; Gold, Goodwin, & Chrousos, 1988; Young, Abelson, & Cameron, 2004).

## EXTERNAL STRESS AND RELATIONSHIP WELL-BEING

The experience of stressors has harmful and lasting consequences for individuals and their relationships (Dickerson & Kemeny, 2004; Kiecolt-Glaser & Newton, 2001; see Neff & Broady, 2011 for exception). Research on newlyweds suggests that stressors experienced outside the context of the relationship (i.e., external stress) influences internal relationship processes and subsequently leads to negative relationship outcomes (Bolger, DeLongis, Kessler, & Wethington, 1989; Repetti & Wood, 1997; Neff & Karney, 2004). This process—commonly referred to as *stress spillover*, whereby stress spills over from one area in life to another—is well documented by researchers investigating the negative effect external circumstances have on marriages (Brock & Lawrence, 2008). External stress is closely linked with less satisfying interpersonal experiences, negative behaviors and evaluations, and ultimately poor relationship outcomes (Neff & Karney, 2004; Story & Repetti, 2006; Bodenmann, Ledermann, & Bradbury, 2007; Karney, Story, & Bradbury, 2005).

One of the first studies demonstrating direct evidence of stress spillover comes from a daily diary study that examined the link between external stress and home experiences among husbands and wives (Bolger et al., 1989). Participants self-reported on daily work experiences (e.g., overloads and arguments with supervisors, co-workers, or subordinates) and evening home experiences (e.g., tensions or arguments with partners) once per day for six weeks. Husbands coming home from work after experiencing distressing encounters with coworkers or supervisors were more likely to report having arguments with their wives in the home that same day. Thus, stress responses in one context can forecast what happens in another context.

Stressful circumstances are also frequently associated with negative behavior and communication patterns among couples (Story & Repetti, 2006; Schulz, Cowan, Cowan, & Brennan, 2004). Male air traffic controllers coming home from a busy work shift are more likely to report withdrawal behavior compared to those coming home from a less busy work shift; stressed participants were more distracted and less involved and interested in social interaction with their wives (Repetti, 1989). Similarly, in a study of 42 married couples, more negatively arousing workdays were linked to more withdrawal and less angry behavior for men and angrier marital behavior for women (Schulz et al., 2004). This work highlights that experiencing stress in one domain contributes to feelings of irritability or frustration and leads to negative experiences in another domain (Story & Repetti, 2006; Schulz et al., 2004).

Moreover, stressors experienced outside the context of marriage interfere with marital quality over time (Neff & Karney, 2004; Bodenmann & Cina, 2009; Randall & Bodenmann, 2009). In an effort to explore the effects of external stressors on relationship quality, Bodenmann and Cina (2006) prospectively assessed 70 couples from Switzerland with a 5-year follow-up. Couples reported on stress in different domains (such as work, finances, and children) and relationship satisfaction. Daily hassles and stress with regard to leisure time were the strongest predictors of low relationship quality. Along these same lines, Neff and Karney (2004) reported that increases in work stress are associated with subsequent decreases in marital satisfaction. Newlywed couples provided information concerning acute stressful experiences (as measured by nonmarital life events), specific relationship perceptions and problems, as well as overall relationship satisfaction every 6 months for the first 4 years of marriage. The experience of work stress led to changes in relationship functioning and evaluations, which subsequently contributed to negative relationship outcomes (i.e., lowered feelings of relationship satisfaction). In sum, these studies underscore the importance of understanding the role that external stress has on the quality and longevity of romantic relationships.

## PHYSIOLOGICAL STRESS RESPONSES AND RELATIONSHIP WELL-BEING

How individuals respond to external stress clearly provides a window into the future overall well-being of relationships; however, it is not yet known whether newly-dating individuals' *physiological* stress responses function as predictors of nonmarital relationship outcomes. Some of the most compelling evidence addressing whether physiological responses forecast relationship outcomes comes from Kiecolt-Glaser and colleagues' (2003) follow-up study of 90 newlywed couples. Stress-related hormone responses to a laboratory-based conflict discussion task during the first year of marriage were used to predict the outcome of those relationships 10-years later. Couple members whose hormone levels were elevated eventually divorced whereas those whose hormone levels were not elevated remained married (Kiecolt-Glaser et al., 2003). Specifically, epinephrine levels of divorced couples were 34% higher during conflict at baseline, 22% higher throughout the day, and 16% higher at night compared to those who remained married. The current research is significant because it reflects a growing body of research demonstrating that stress-related hormone responses function as potential determinants of relationship outcomes.

Previous studies on the links between stress within marriage and relationship outcomes, however, are limited in two ways. First, this work focuses exclusively on marital relationships, thus making it hard to generalize to nonmarital relationships. Examining newly-dating relationships would allow for a way to identify patterns of physiological functioning among at risk couples before they get married. Second, past work examines stress-related hormone responses derived from within the relationship (e.g., parenting styles, division of labor), which limits our understanding of how individuals experience and respond to stress *in general*. In light of the findings on 'stress spillover'—which imply that individuals' abilities to manage stress is a significant predictor of relationship outcomes—it is reasonable to expect that individuals' *general stress responses* (i.e., physiological reactivity and recovery) are linked with the overall (future) well-being of romantic relationships.

Standardized stressors enable researchers to assess individuals' general stress responses—thus providing a fruitful avenue for addressing these limitations. The Trier Social Stress Test (TSST; Kirschbaum et al., 1993), specifically, incorporates motivated performance tasks, uncontrollability, and social-evaluative threat—all of which are key components to reliably eliciting cortisol (Dickerson & Kemeny, 2004). The methodological advantages of the TSST have led to its widespread use in psychophysiology and relationship research. The TSST generally involves a waiting period upon arrival, an anticipatory speech preparation period, and a test period in which participants give a speech followed by completing a mental arithmetic task in the presence of an unsympathetic panel of judges, followed by a recovery period (Kirschbaum et al., 1993). The TSST is used to examine intra- and inter-individual variation in the HPA axis response and the dysregulation of the HPA axis response on individual well-being (Foley & Kirschbaum, 2010).

Physiological stress responses are often measured with respect to cortisol reactivity, recovery, and area under the curve (AUC). Whereas *reactivity* refers to the degree of elevation in response to a stressor, *recovery* refers to the degree of delay in returning to pre-stress (i.e., baseline) levels following a stressor. It should be noted that in the current study two forms of recovery will be assessed: *TSST recovery,* which refers to recovery or the rate of decline in stress hormones following the TSST, and *tonic recovery*, which refers to recovery in stress hormones after an individual has shown up to an experimental setting (Balodis, Wynne-Edwards, & Olmstead, 2010). Although examining the magnitude of stress responses from baseline (i.e., reactivity) is valuable in its own right, focusing solely on reactivity is limiting in that it provides only a partial indication of how individuals view and experience stressors. There is consistent evidence that examining recovery strengthens the interpretation of results (Linden, Gerin, & Christenfeld, 1997). Research examining physiological reactivity to a psychological challenge demonstrate that while there may be intra-individual similarity in reactivity to stressors, the manner in which individuals *recover* is what distinguishes individuals from one another (cf. Jamieson & Lavoie, 1987; McCubbin, Cheung, Montgomery, Bulbulian, & Wilson, 1992). Tonic recovery provides unique information about how individuals naturally recover or habituate to their environments (Balodis, Wynne-Edwards, & Olmstead, 2010). The initial change between hormone samples collected upon arrival to the laboratory and hormone samples collected immediately prior to a challenge task may represent an innate state of adaptiveness or arousal that provides information about how an individual might respond to the environment (Balodis et al., 2010). Thus, tonic recovery offers additional explanatory power for studying the stress-relationship pathway. Additionally, *AUC*—which represents total hormone output—is largely reflective of a failure of the body to adequately regulate the HPA axis following stress (Kennedy, Cryan, Quigley, Dinan & Clarke, 2014). Extended hormone exposure resulting from prolonged HPA axis activation can be damaging and is associated with a number of negative health consequences (Miller, Chen, & Zhou, 2007). Studies examining total hormone output demonstrate associations between greater hormone concentrations and increased risk of disease such as chronic illness and hypertension (Miller et al., 2007; McEwen & Seeman, 2003). Moreover, the assessment and interpretation of AUC provides a comprehensive examination of the intra- and inter-individual factors that may discriminate those who will experience unfavorable relationship outcomes from those who will experience favorable relationship outcomes.

Previous work examining the relationship-stress link provide support for the hypothesis that nonadaptive responses influence relationship outcomes. This work demonstrates that the manner in which people respond to stress, in general, can affect what might go on in their relationships via self-regulatory processes (Bodenmann & Shantinath, 2004; Randall & Bodenmann, 2009; Rusbult, Yovetich, & Verette, 1996).

Newlywed couples experiencing higher levels of external stress are more likely to become depleted and in turn, are more likely to engage in destructive behaviors that are associated with poor relationship outcomes (Buck & Neff, 2012). Given that physiological responses to stress likely reflect the inability to manage stress (Gunnar, 1994), it could be reasoned that nonadaptive responses will be linked to poor relationship outcomes. Specifically, slow rates of recovery and increased total cortisol output will increase the likelihood of experiencing a breakup. Together this work suggests that physiological responses likely parallel how people respond to stress, in general, and may ultimately lead to eventual relationship deterioration.

Although the vast majority of research examining the link between stress responses and relationship outcomes focuses on how individuals respond to stress *within* their relationships, there is limited work examining how individuals respond to stress *outside* their relationships. As noted above, we know that stress derived from within the relationship is a strong predictor of what might happen to the relationship later on (Neff & Karney, 2009; Lewandowski, Mattingly, & Pedreiro, 2014). It is less clear, however, what role responses to stress derived from outside the relationship play in predicting later relationship outcomes. Given that stress is ubiquitous and affects everyone at some point in time, it is important to understand how all types of stress (both inside and outside of the relationship) affects the quality and longevity of romantic relationships. This understanding would not only provide a more comprehensive understanding on the ways in which stress undermines relationships, but it would also provide additional insight on specific ways to intervene.

## OVERVIEW OF THE CURRENT STUDY

The ability to adapt to stress has important implications not only for health and well-being (McEwen, 2008; Juster, McEwen, & Lupien, 2010) but also for romantic relationships (Karney & Bradbury, 1995; Kiecolt-Glaser et al., 2003). Yet, research investigating the consequential influence that acute physiological responses to stress, *in general*, have in determining the outcome of relationships remains sparse. How individuals respond to and manage stress is known to serve as an important indicator of marital dissolution (Kiecolt-Glaser et al., 2003; Neff & Karney, 2009), but further study is needed to determine whether physiological responses forecast relationship outcomes. In addition, examining the relationship-stress link prior to marriage has received little attention. The present study examines the relationship-stress link by testing whether newly-dating individuals' general stress responses (i.e., reactivity and recovery) to a standardized speech and math task predict subsequent relationship status.

The core hypothesis for the present study is:

*Individuals who display atypical hormone responses (i.e., take longer to recover, demonstrate greater increases in total cortisol output) to a novel setting and a standardized stressor will be more likely to report experiencing a breakup than individuals who display adaptive responses to the same settings.*

# METHOD

## PARTICIPANTS

One hundred and sixteen individuals (84 female; 32 male; mean age: 20.3 years, SD: 1.7, range 18-25) participated in a nine-month longitudinal study on the health consequences of nonmarital romantic relationship transitions. To be eligible to participate, individuals were required to be in good mental and physical health and had to be involved in a nonmarital romantic relationship less than six months duration (mean duration: 3.78 months, SD: 2.56). Forty-seven percent of participants self-identified as Caucasian, thirty percent of participants described themselves as Asian, and nineteen percent described themselves as Other.

Participants were randomly assigned to one of two groups during different times in their relationships—those who underwent the TSST while they were transitioning into their romances and those who underwent the TSST either following the dissolution of their relationship or after their relationship lasted for the nine-month duration of the study. Analyses for the current study focused only on those who underwent the TSST while they were transitioning into their romances. Five cortisol values across 4 participants were removed because they were 3 standard deviations above the mean. None of the participants were excluded from the study because of other exclusion criteria (Smyth et al., 2013).

## PROCEDURE

### Overview

Participants were recruited through online advertisements and flyers posted around the university campus and surrounding community. Those interested in the study were directed to a secure website where they completed an online screening form. Eligible participants were invited to participate in a one-time laboratory visit and a series of online surveys to be completed over nine months. Prior to coming into the laboratory, participants were asked to refrain from food, beverages, physical exercise, and smoking for at least one hour prior to participation. All study sessions were conducted between 2 p.m. and 6 p.m. to control for diurnal patterns in cortisol secretion (Kirschbaum & Hellhammer, 1994). Upon completion of the study, participants were debriefed and compensated for their participation.

### Screening questionnaire

Participants completed an online screening that assessed factors known to influence HPA-functioning and salivary cortisol levels, including use of tobacco products, medications, history of hormone problems, depression, anxiety, body mass index (BMI), night shift work, and being pregnant. Participants who reported any of these conditions were excluded for participation in the study. Women were tested in the luteal phase of their menstrual cycle. Lastly, women using oral contraceptives were not excluded from participation because it is common for unmarried women of reproductive age to use oral contraceptives (Mosher, Martinez, Chandra, Abma, & Willson, 2004).

### Biweekly measures

Individuals were asked to complete a brief online event-identification survey every 2 weeks for the entire nine months of the study. At each biweekly survey, participants reported on relationship status, relationship dependence, as well as mental and physical health functioning. Analyses for the current study will focus primarily on the relationship status assessment.

**Laboratory session**

The Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993) consists of a 5 min free speech task and a 5 min performance of a mental arithmetic challenge (serial subtraction) in the presence of an audience who was unknown to the participant. Upon arrival to the laboratory participants were asked to sit quietly for approximately 30 min. Next, participants were escorted to an interview room with a microphone stand connected to a video camera and a panel with three examiners. Participants were informed that they had 10 min to prepare a 5 min speech for their ideal job. Before being taken back to the initial room to prepare for the speech, a research assistant asked the participants to identify their ideal job. After the 10 min preparation period, participants were taken back to the interview room to begin describing why they would be an ideal candidate for the job. If at any time during the speech participants paused for more than 10 sec, one of the judges stated in an authoritative tone, "Please continue, you have XX min/sec remaining." At the completion of the speech task, participants were asked to perform the mental arithmetic challenge by counting backwards from a predetermined number by 13 (i.e., "Count backwards out loud, starting at the number 1687 in steps of 13."). If participants made an error, one of the judges replied, “Incorrect, please start again from XXX.” Importantly, the tasks utilized in this laboratory stressor characterize social-evaluative threat (i.e., situations that involve negative evaluation by others; Dickerson, 2008), which are commonly known to elicit robust increases in cortisol (Dickerson & Kemeny, 2004).

**Hormonal assays**

Salivary cortisol is a reliable indicator of free cortisol in plasma, and increases within minutes in response to acute stressors (van Eck, Berkhof, Nicolson & Sulon, 1996). During the laboratory session, participants provided saliva samples for the assessment of reactivity, recovery, and area under the curve (AUC) of cortisol to the TSST (Kirschbaum et al., 1993; Dickerson & Kemeny, 2004). Saliva samples were collected upon arrival to the lab (Time 0), 2 min (baseline) prior to initiation of the TSST (Time 1), and 28 (after the stressor ended; Time 2), 45 (to capture cortisol peak; Time 3) and 63 min (short-term recovery; Time 4) after initiation of the TSST using the Salivette (Sarstedt)—a small piece of sterile dental cotton. Participants were asked to keep the salivette in their mouth for two minutes, or until the sample was fully saturated. Levels of cortisol were determined according to the methods of SalimetricsLLC expanded range high sensitivity salivary cortisol enzyme immunoassay kit. All samples were frozen at –20 °C until assayed.

## MEASURES

**Cortisol**

Three cortisol indices were measured: *tonic recovery* (i.e., recovery in stress hormones after an individual has shown up to an experimental setting) reflecting change in cortisol from Time 0 to Time 1, *TSST recovery* (i.e., recovery or rate of decline in stress hormones following the TSST) reflecting change in cortisol from Time 3 to Time 4, and *area under the curve (AUC)* reflecting total cortisol output from Time 1 to Time 4. AUC was calculated using the trapezoidal method described by Pruessner and colleagues (2003). The formula for calculating AUC is AUC = $t_1(m_1+m_2)/2 + t_2(m_2+m_3)/2 + t_3(m_3+m_4)/2$; where $m$ = the individual measurement; $t$ = the distance between measurement; $n$ = the total number of measurements (Pruessner et al., 2003).

### Relationship status

Breakup status was measured with the following question: “In the last survey, you indicated that you were romantically involved with XXX. As of today, are you still romantically involved with XXX?” A two-level breakup status variable was derived, consisting of the group of participants whose relationships persisted (dummy coded as 0) versus the group whose relationships ended (dummy coded as 1).

## ANALYTIC STRATEGY

### Data screening

Data was screened and adjusted for outliers and distributional anomalies that may have violated assumptions. A log transformation was applied to all cortisol data to correct for positive skeweness (Tabachnick & Fidell, 2001). Statistical analyses were performed on transformed data, but figures and tables reflect original data for interpretation purposes. Outliers (i.e., cases +/- 3SD from the mean) within the transformed variables were excluded in order to prevent a distortion of parameter estimation and significance of inferential analyses (Smyth, Hucklebridge, Thorn, & Evans, 2013).

**Statistical analysis**

The focus of the data analyses involved examination of they hypothesis in two ways: a) patterns of change in hormone levels (i.e., cortisol) among those whose relationships persisted versus those whose relationships ended, and b) the prediction of relationship status (together vs. not) using these patterns of change in hormone levels. Associations between patterns of change in hormone levels and relationship status were analyzed using multilevel modeling (MLM)—a class of statistical models developed for the analysis of nested data (Garson, 2013; Blackwell, Mendes de Leon, & Miller, 2006). Additionally, multilevel logistic regression models were conducted to test the effects of tonic recovery, TSST recovery, and AUC on relationship status (together vs. not).

In order to examine patterns of change in hormone levels (i.e., cortisol) among those whose relationships persisted versus those whose relationships ended, group analysis were conducted using MLM to see how cortisol over time varies as a function of relationship status. In equation 1, $Y_{ij}$ represents the hormone measure for occasion *i* within individual *j*, and TIME represents an index for the occasion, where TIME = 1, 2, 3, 4 for the four measurement occasions. In order to account for the curvilinearity observed in the cortisol trajectory, a nonlinear function of time, $\text{TIME}^2$, was entered. Therefore, change in hormone levels was predicted as both a linear and a quadratic function of time according to the model:

Level 1: $Y_{ij} = \beta_{0j} + \beta_{1j}(\text{TIME}) + \beta_{2j}(\text{TIME}^2) + e_{ij}$ (1)

where $\beta_{0j}$ is the intercept for individual *j,* $\beta_{1j}$, is the slope or rate of linear change for individual *j*, $\beta_{2j}$ is the rate of quadratic change for individual *j,* and $e_{ij}$ is the error in predicting the hormone level from time. It is assumed that the residual $e_{ij}$ is normally distributed, with a mean zero and variance $\sigma^2_{ij}$. Thus, equation 1 is the first, within-person, stage of analysis and is simply the regression of the outcome variable *Y* (cortisol) on time.

The second, between-person, stage of analysis determines which person-level characteristics (i.e., relationship status; GROUP 1=breakup; GROUP 0=together) explain within-person β coefficients according to the models:

Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{GROUP}) + r_{0j}$ (2)

Level 2: $\beta_{1j} = \gamma_{10} + \gamma_{11}(\text{GROUP}) + r_{0j}$ (3)

Level 2: $\beta_{2j} = \gamma_{20} + \gamma_{21}(\text{GROUP}) + r_{0j}$ (4)

where in equation 2, $\beta_{0j}$ is represented as a function of $\gamma_{00,}$ the mean hormone level across individuals when all predictors are zero after adjusting for linear change, $\gamma_{01}$, the overall regression coefficient for the relationship (slope) between GROUP and cortisol, and $r_{0j}$, the deviation from the mean for individual *j*. Similarly for slopes $\beta_{1j}$ and $\beta_{2j}$ in equation 3 and 4, respectively. Thus, Level 2 models examine how each of the average slopes (i.e., $\beta_{1j}$ and $\beta_{2j}$), which represent the relationship between cortisol and time, vary as a function of relationship status.

In order to test the effects of TSST recovery, tonic recovery, and AUC on relationship status (together vs. not), multilevel logistic regression techniques were utilized. Multilevel logistic regression can handle binary outcomes. Estimating the effects of cortisol on relationship outcomes proceeded as follows. The statistical significance of potential intervening variables such as alcohol consumption, cigarette smoking, BMI, sleep quality, medications, birth control use, and regularity of menstrual cycle were entered in the model. There is growing evidence that nonadaptive responses to stressors are partly influenced by personality characteristics such as neuroticism (i.e., a tendency towards negative emotions or emotional distress including nervousness, hopelessness, and guilt; Lahey, 2009). For instance, several studies suggest that individual high in neuroticism have larger and more prolonged responses to stressors (Norris, Larsen, & Cacioppo, 2007; Vogeltanz & Hecker, 1999). Nonetheless, because neuroticism is related to physiological responses to stress, neuroticism was also entered as a statistical control in the model.

All variables with significant effects identified in the model were included in all subsequent models that predict relationship outcome. Due to the correlated nature of the cortisol indices, three separate models were conducted using the following equation:

Level 1: $\text{logit}P(Y_{ij} = 1|b_i) = \beta_{0i} + \beta_{1i}(time) + \beta_{2i}(\text{CORT}) + \beta_{3i}(time \times \text{CORT})$ (5)

where $p$ represents the binary outcome and the probability of event occurrence (i.e., reporting a breakup; $Y = 1$) for individual $i$, $\beta_{0i}$ is the intercept for individual $i$, $\beta_{1i}$, is the cortisol recovery slope. The $e_i$ is omitted from the model because its variance, denoted $\sigma^2$, follows directly from the success probability (i.e., $\sigma^2 = p[1-p]$), and is therefore assumed fixed under the log-odds transformation (Raudenbush & Bryk, 2002). Thus, equation 5 represents the regression of the outcome variable *p* (i.e., relationship status) on the three separate cortisol indices. The Level 2 equations are:

Level 2: $\beta_{0j} = \gamma_{00} + r_{0j}$ (6)

Level 2: $\beta_{1j} = \gamma_{10} + r_{0j}$ (7)

Level 2: $\beta_{2j} = \gamma_{20} + r_{0j}$ (8)

Level 2: $\beta_{3j} = \gamma_{30} + r_{0j}$ (9)

where $\beta_{0j}$ is represented as a function of $\gamma_{00}$ is the mean intercept across individuals when all predictors are zero, and $r_{0j}$ is the deviation from the mean generated from a normal distribution with mean zero and variance $\sigma^2_r$. Similarly for slopes $\beta_{1j}$, $\beta_{2j}$, and $\beta_{3j}$ in equation 6, 7, 8, and 9. Interpretation of the regression parameters is *not* in terms of the response proportions but instead in terms of the underlying variate defined by the logit transformation logit*(x)* = ln[*x*/(1-*x*0]. The logic link function is nonlinear and transforms the proportions, whcih are between 0.00 and 1.00, into values that range between -∞ to +∞ (Raudenbush & Byrk, 2002).

# RESULTS

Descriptive data for demographic characteristics and cortisol indices of the two groups (i.e., those who remained together and those who broke up) are presented in Table 1 and a graphic illustration of cortisol means are presented in Figure 1. Findings showed that Time 3 peak cortisol levels ($M = 0.19$, $SD = 0.11$) were significantly higher than baseline levels ($M = 0.12$, $SD = 0.05$) in the group as a whole, $t(111) = -6.44$; $p < 0.001$, suggesting that the psychological stressor was effective in activating the physiological stress response. There were no significant group differences in age, $t(114) = 0.13$, $p = 0.90$, gender, $X^2$ (1, $N = 114$) = 0.79, $p = 0.43$, and relationship length, $t(114) = 1.03$, $p = 0.31$. The difference in cortisol level between the together ($M_{\text{Tog}} = 0.12$, $SD = 0.05$) and breakup ($M_{\text{Bu}} = 0.12$, $SD = 0.05$) groups at baseline was not statistically significant [sample 2; $t(113) = -0.34$ $p = 0.73$]. There were no significant group differences in cortisol level between groups for Time 2, 3, and 4 [$t(114) = -0.59$, $p = 0.55$; $t(111) = 0.60$, $p = 0.55$, $t(114) = -0.85$; $p = 0.40$, respectively]. Additionally, the AUC scores did not differ by group, $t(114) = -0.62$, $p = .54$.

The core hypothesis was examined in two ways. Initially, multilevel modeling repeated measures was utilized to test how cortisol responses change over time between those whose relationships persisted and those whose relationships ended. When including control variables (e.g., relationship length, baseline cortisol, neuroticism), the stress protocol induced significant increases in cortisol (linear term: $\beta = 0.18$, $SE = 0.04$, $p < 0.001$; quadratic term: $\beta = -0.05$, $SE = 0.01$, $p < 0.001$). Those whose relationships persisted had lower intercepts than those whose relationships ended, but this difference was not statistically significant ($\beta$ = 0.01, *SE* = 0.01, *p* = 0.72). There was also a non-significant trend for cortisol over time for those whose relationships persisted compared to those whose relationships ended (linear term: $\beta$ = 0.02, *SE* = 0.06, *p* = 0.79; quadratic term: $\beta$ = -0.006, *SE* = 0.02, *p* = 0.70). In other words, all individuals responded at similar rates despite the outcome of their relationship (see Table 2).

Subsequently, the effect of individual-level predictors on individual-level outcomes was examined; specifically, whether cortisol indices predict relationship outcomes (i.e., breakup status). The effect did not reach statistical significance. Individuals who displayed nonadaptive hormone responses (i.e., took longer to recover, demonstrated greater increases in total cortisol output) to a novel setting and a standardized stressor were no more likely to experience a breakup than individuals who displayed adaptive responses to the same settings (Tonic recovery: OR = 0.90, 95% CI 0.25-3.32; TSST recovery: OR = 0.49, 95% CI 0.82-1.2; AUC: OR 0.99, 95% CI 0.94-1.13; see Table 3).

# DISCUSSION

This study examined whether general stress responses (i.e., reactivity and recovery) are associated with relationship outcomes among newly-dating individuals. Based on results from multilevel analysis, there was no support for the hypothesis that physiological responses to a standardized stress task predict the likelihood of experiencing a breakup. There are two possible conclusions that can be derived from this study's results: 1) we accept the results as true and confirm that there is no relationship between general stress responses and nonmarital relationship outcomes, and 2) the findings may be a result of a type 2 error (i.e., concluding that there is no relationship when in fact there is).

If we accept these findings as reflecting reality at the population level, then the absence of the hypothesized effect suggests that the ability to respond adaptively to stress may not subsequently predict the likelihood that dating-couples will experience a breakup. Even though this finding is inconsistent with previous research demonstrating that the manner in which individuals respond to stressors can influence relationship quality and longevity (Rusbult et al., 1996; Karney & Bradbury, 1995; Kiecolt-Glaser et al., 2003), it nonetheless suggests that individuals are perhaps better than previously thought at compartmentalizing the various stressors in their lives, such that stressors in one domain do not necessarily spillover into unrelated domains (Neff & Karney, 2004).

How can we understand these unprecedented findings? The first possibility to explore concerns whether general stress responses should be considered a primary cause of romantic breakup. While *relational* stressors are directly and robustly associated with relationship outcomes (e.g., negative communication patterns and dyadic conflicts, health problems of one partner; Bodenmann, 2005; Bodenmann et al., 2007), general stress responses may only be indirectly related to an eventual breakup. As such, it is important to explore what factors may both moderate and mediate the relationship between nonadaptive stress-responses and relationship deterioration.

A broad group of potential moderators includes constructs that are related to the resources individuals have to manage stress in everyday life: emotion regulation skills, coping strategies, and partner support. For example, strong emotion regulation skills can lead to more satisfying couple relationships (Halford, Wilson, Lizzio, & Moore, 2002), whereas poor emotional regulation skills lead to decreases in relationship satisfaction and increases in argumentative behaviors (Baumeister, 2002; Buck & Neff, 2015). Thus, stress responses may be less likely to damage the personal relationships of individuals with strong emotion regulation skills, and more likely to damage the relationships of those with poor emotional regulation skills. Similarly, the type of coping strategies individuals engage in to down regulate stress over time may subsequently influence whether stress in a non-relationship domain is pervasive enough to disrupt relationship processes. Additional research efforts should be directed at understanding the way people cope with stressful situations. This is especially pertinent given that poor physiological responses to a stressor may depend on how individuals emotionally and behaviorally regulate to or cope with a situation (Gunlicks-Stoessel & Powers, 2009). For example, maladaptive coping strategies may leave stress unresolved and result in the inability to physiologically respond adaptively (Gunnar, 1994). In a related vein, partner support must also substantively contribute to whether general stress responses lead to eventual relationship deterioration. That is, individuals with high levels of partner support may be buffered against stress spillover and may be more likely to stay together (as per the findings), whereas the relationships of individuals with low levels of partner support may be at risk for spillover and eventual deterioration. Taken together, our failure to measure these types of potential moderators means that the present study can only conclude that there is not a direct path between general stress reactivity and breakup status; however, there may be many variables that moderate this relationship.

Additionally, certain characteristics of our sample may have been problematic. Specifically, the sample consisted of a restricted age range (18-25), was overwhelmingly female, and lacked cultural diversity (majority Caucasian). Whereas a diverse group of individuals may have varied more widely on the measures of interest, the homogenous nature of the present sample limits the generalizability of our findings.

This study also assessed responses to only one type of stressor; that is, a standardized speech and math task. The underlying objective of studying responses to standardized stressors such as the TSST is that responses to such tasks reflect the way people will physiologically respond to stress in their everyday lives (Kidd, Carvalho, & Steptoe, 2014). Thus, an individual who responds poorly to acute stress in the laboratory will also respond poorly to stress experienced outside of the laboratory. However, investigating cortisol responses to a standardized stress task involves assessing acute responses to short-term stress under artificial conditions that are not often encountered on an everyday basis (Kidd et al., 2014). Therefore, responses to a one-time speech and math task may not reflect the way people will physiological respond to an everyday stressor (e.g., sitting in traffic or having an argument with a coworker). For example, having an argument with a coworker may have more dramatic emotional and physiological consequences compared to engaging in one-time laboratory experiment. Although previous literature has demonstrated that responses to different types of stressors may not be uniform (Dickerson & Kemeny, 2004), further research should examine what is it about responses to certain conditions or stressors that would make individuals more susceptible to negative outcomes including relationship deterioration.

Because the individuals in this study were in newly-dating relationships, they may not have experienced a similar spillover effect described in previous studies that examine those in already established relationships (e.g., marital relationships). One potential reason why newly-dating individuals may not experience a similar spillover effect relates to whether these individuals are cohabiting with their partners. People who do not live with their partner may not have a partner to come home to; therefore the stress these people experience outside of their relationships may not have the opportunity to spill over into their relationships. Take for example, long distance relationships (LDRs), where partners live miles apart. People in LDRs do not experience a great amount of face-to-face contact and as a result, must rely on non-physical ways of communicating and connecting emotionally such as savoring the moments they communicate with one another (Borelli, Rasmussen, Burkhart, & Sbarra, 2014). These individuals may therefore be more resistant to the negative effects of stress spillover. In order to better understand how general stress responses may influence dating relationship outcomes, future research should examine the extent to which noncohabiting and cohabiting individuals interact with their partner on a day-to-day basis.

Future research should also utilize survival analysis methods (instead of logistic regression methods) to examine the associations between general stress responses and breakup status. Whereas logistic regression considers the proportion of new cases that develop in a given period of time (i.e., cumulative incidence), survival analysis differs in that it evaluates causative contributions to the occurrence and timing of the event of interest instead of a proportion (Wang, Brown, An, Yang, & Ligmann-Zielinska, 2013). Moreover, survival analysis uses temporal information more fully and as a result, holds great promise for using physiological responses to predict the length of time it takes to breakup.

It is important to note that this study does have its strengths. This is the first study of its kind that looks at whether physiological responses unfold within dating couples. This study also provides a methodological contribution by utilizing multilevel modeling to analyze trajectories of HPA reactivity and recovery while also allowing for the ability to examine both within- and between-level effects within one model. In sum, the findings from this study suggest that associations between physiological responses to general stress and breakup are not significant, although this may be due to unmeasured individual differences as well as our use of a particular type of stress induction task.

**Table 1**

*Descriptive Statistics for Key Study Variables*

| | **Breakup** | | **Together** | | **Total** | |
|---|---|---|---|---|---|---|
| | *n* | *M* (*SD*) | *n* | *M* (*SD*) | *n* | *M* (*SD*) |
| Age | 44 | 20.3 (1.74) | 72 | 20.3 (1.60) | 116 | 20.3 (1.7) |
| Female | 30 | 0.68 (.48) | 54 | 0.75 (.44) | 84 | 0.72 (.45) |
| Relationship Length | 44 | 3.42 (1.83) | 72 | 3.91 (2.83) | 116 | 3.72 (2.50) |
| Cort 1 (Time 0) | 44 | 0.15 (.06) | 72 | 0.14 (.07) | 116 | 0.14 (.07) |
| Cort 2 (Time 1) | 43 | 0.12 (.05) | 72 | 0.12 (.05) | 115 | 0.12 (.05) |
| Cort 3 (Time 2) | 44 | 0.17 (.10) | 72 | 0.16 (.11) | 116 | 0.17 (.11) |
| Cort 4 (Time 3) | 42 | 0.18 (.11) | 71 | 0.19 (.12) | 113 | 0.19 (.11) |
| Cort 5 (Time 4) | 44 | 0.16 (.13) | 72 | 0.15 (.07) | 116 | 0.15 (.10) |
| AUC | 44 | 10.21 (4.35) | 72 | 10.15 (5.38) | 116 | 10.17 (5.01) |

*Note*. Total *N*'s range from 113 to 116 due to occasional missing data. Salivary cortisol levels (means; $\mu$g/dL).

**Table 2**

*Mixed Model Solution for Fixed Effects Predicting Cortisol*

| | | | | | 0.95 *CI* | |
|---|---|---|---|---|---|---|
| | *b* | *std. error* | *t* | *df* | LL | UL |
| Intercept | 0.84*** | 0.05 | 18.42 | 255 | 0.75 | 0.93 |
| Level 1 | | | | | | |
| Time | 0.18*** | 0.04 | 4.74 | 126 | 0.10 | 0.25 |
| $Time^2$ | -0.05*** | 0.01 | -4.61 | 122 | -0.07 | -0.03 |
| Level 2 | | | | | | |
| Time*Group | 0.02 | 0.06 | 0.27 | 126 | -0.10 | 0.14 |
| $Time^2$*Group | -0.01 | 0.02 | -0.39 | 122 | -0.04 | 0.03 |

**p* < .05; ***p* < .01; ****p* < .001

**Table 3**

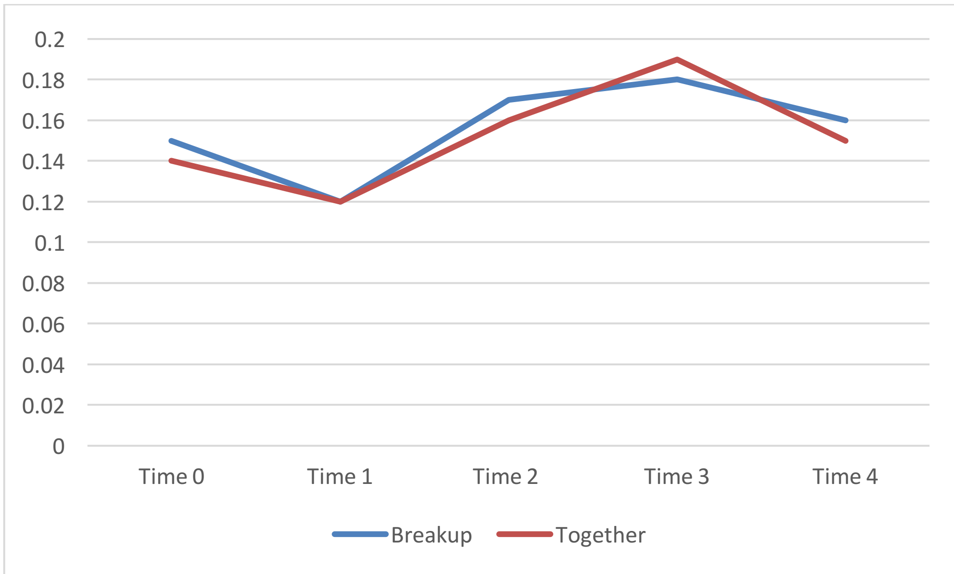
*Odds Ratios for the Effects of Tonic Recovery, TSST Recovery, and AUC on Breakup Status*

| | OR (95% CI) | *p*-value |
|---|---|---|
| Tonic Recovery | 0.90 (0.25-3.32) | 0.86 |
| TSST Recovery | 0.49 (0.82-1.2) | 0.93 |
| Area Under Curve (AUC) | 0.99 (0.94-1.13) | 0.48 |

*Note*. *n* = 116. Data are presented as odds ratio (95% confidence interval). Abbreviations: OR, odds ratios; CI, confidence intervals. *p < .05.

**Figure 1**

*Group Means for Cortisol Trajectories Over Time*




*Note*. $n$ = 116. Salivary cortisol levels (means; $\mu$g/dL).

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