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ENERGIZED BY LOVE: PHYSIOLOGICAL CONSEQUENCES OF PARTNER REFLECTION

Sarah Claire Evans Stanton

ENERGIZED BY LOVE: PHYSIOLOGICAL CONSEQUENCES OF PARTNER REFLECTION

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Sarah C. E. Stanton

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CERTIFICATE OF EXAMINATION

Supervisor	Examiners
______________________	______________________
Dr. Lorne Campbell	Dr. Bertram Gawronski
	______________________
Supervisory Committee	Dr. James Olson
______________________	______________________
Dr. Bertram Gawronski	Dr. Leslie Janes

The thesis by

Sarah Claire Evans Stanton

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Date______________________

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Abstract

Prior research has demonstrated that when individuals think about their romantic partner, they experience specific physiological responses (e.g., cortisol reactivity). Guided by these findings, the present study explored the potential physiological and behavioral benefits associated with partner reflection; specifically, the idea that individuals would be physically energized by partner reflection, and that this energy would allow them to persevere when presented with a complex task. Results revealed that participants who thought about their romantic partner exhibited both short-term and long-term increases in blood glucose, relative to those who thought about their morning routine or a friend. These increases in glucose were also uniquely associated with positive affect for those who reflected on their romantic partner in particular. Moreover, partner reflection in particular seemed to buffer glucose levels against a difficult task designed to deplete self-regulatory resources, and yielded trends for enhanced performance on a subsequent task.

Keywords: love, glucose, partner reflection, ego depletion, self-regulation

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"Love is that splendid triggering of human vitality."

–José Ortega y Gasset

The occurrence and influence of physiological responses within romantic relationships has recently become the focus of a great deal of research. Studies investigating neurological correlates of relationship processes such as falling in love and social support, in addition to those that examine physiological activity in various body systems that occur as a result of relationship stimuli, have yielded useful and provocative knowledge with implications for health and physical functioning. However, much of what is known about stress responses in relationships focuses on how individuals respond to negative relationship stressors. Equally interesting are studies that explore potential positive stress in relationships and how this type of stress can affect physiology and behavior, which are only very recently beginning to flourish. One area of research in relationship physiology has begun to examine an arguably simple relationship stimulus that may have potent positive consequences in terms of distinct stress responses in the body; namely, thinking about the romantic partner, or partner reflection.

Partner reflection may be a powerful source of energy, as love is associated with a number of unique physiological outcomes. The experience of love is thought to activate the motivation, reward, and emotion systems in the brain (Aron et al., 2005) and to be related to specific hormone variation (Emanuele et al., 2006; Loving, Crockett, & Paxson, 2009; Marazziti & Canale, 2004). Individuals experiencing love also tend to be emotionally affected (both positively and negatively) by their thoughts and feelings about their romantic partner, such that their emotions can influence their subjective well-being

(Kim & Hatfield, 2004). Love can therefore be arousing both physiologically and psychologically, leading to acute responses in the body that may be positive or negative.

When faced with a stressful experience, body systems such as the sympathetic-adrenal-medullary (SAM) system and the hypothalamic-pituitary-adrenal (HPA) axis operate at higher or lower levels than during normal homeostasis. It is the discrepancies of these systems that are relevant to subsequent physiological response; specifically, discrepancies in the SAM system are related to short-term, more immediate responses, while those in the HPA axis are related to long-term, more delayed responses. In this way immune, metabolic, and neural responses to stress can have both short- and long-term consequences (McEwen, 1998).

The SAM system and HPA axis specifically yield variation in catecholamines (e.g., norepinephrine) and hormones (e.g., cortisol) that may work in concert to impact subsequent physiology and behavior. That is, because the HPA axis can sustain and modify SAM system activity (Adam & Epel, 2007), it may be the case that short-term bodily responses to a stressful stimulus impact later behavior. Furthermore, the physiological variation that results from these two systems in the face of stress may be triggered by partner reflection to impact additional metabolic processes in the body that afford an individual energy. In other words, it may be the case that the hormones associated with love and partner reflection can translate into both immediate and delayed physical energy (e.g., glucose) and also impact long-term behavioral processes (e.g., self-regulation).

The purpose of the current study was to extend the literature on how relationships influence bodily and behavioral outcomes by examining how partner reflection may act as positive stress. First, this thesis reviews the current research on how relationship processes have been shown to affect the human body, with a particular focus on stress response and the distinction between different forms of stress. Next, the author details how specific body systems may elicit eustress (i.e., positive stress) responses and presents relevant research examining physiological responses to relationship processes within these systems. An overview of self-regulation and ego depletion, including mechanisms to bolster against and counteract ego depletion, is then discussed. Finally, the author outlines the present research, which further investigated the physiological and self-regulatory consequences of partner reflection.

Relationships and the Body

The study of physiological processes in relationships is a currently blossoming area of research. However, the majority of research on physiological processes in relationships to date has focused largely on negative consequences. For instance, Kiecolt-Glaser and colleagues (2005) showed that individuals experiencing hostile conflict exhibit slower healing of physical wounds as well as lower levels of proinflammatory cytokines at the site of the wound. Additionally, the researchers showed that couples who generally demonstrate hostile behavior toward each other exhibit more frequent and sustained high levels of proinflammatory cytokines. While proinflammatory cytokines can be helpful in the short-term by enhancing the healing process, chronically high levels are linked to poor health and accelerated age-related diseases. Hostile conflict, therefore, seems to have harmful bodily consequences in both the short- and long-term.

Negative stress in relationships has effects that also extend beyond physical injury. Nealey-Moore et al. (2007) found similarly that marital stress increased risk for cardiovascular disease through elevated systolic blood pressure, heart rate, and cardiac output. Individuals with fewer good social relationships have a greater likelihood for developing the common cold as well (Cohen, Doyle, Turner, Alper, & Skoner, 2003). Additionally, separation from a romantic partner has been linked to sleeping problems, greater subjective stress and physical symptoms, and augmented physiological response, although these outcomes are gradually ameliorated upon reunion (Diamond, Hicks, & Otter-Henderson, 2008).

Clearly, the research on negative bodily responses to relationship processes is both diverse and informative regarding how individuals are affected by their relationships. Nonetheless, solely examining potential harmful consequences of relationship stressors can be limiting. To fully understand how romantic relationships affect the body, researchers must also investigate the possibility of relationships producing positive physiological responses. Indeed, as Lovallo (2005) states, "If psychological events can produce stress effects in the body, it should be in principle possible for psychological events to have beneficial effects" (p. 233). It is easy to conceptualize psychological and physical stress as negative stimuli that result in deleterious outcomes, but it is likely that not all stress is bad stress. On the contrary, new empirical support in recent years has demonstrated that certain forms of stress can be beneficial for the body.

What is Stress?

Over the years, stress has garnered quite a destructive reputation, for a great deal of literature defines stress by its association with negative outcomes. For example, Wright, Cohen, and Cohen (2005) purport that stress should be conceptualized as "a social *pollutant* which can be 'breathed' into the body and disrupt a number of physiological pathways" (p. 27; italics added). In other words, stress acts as a poison for the body. The lay definition of stress is equally pessimistic; the Oxford English Dictionary labels stress as "an *adverse* circumstance that disturbs...the normal physiological or psychological functioning of an individual" (Stress (psychology and biology), 2011; italics added). Nevertheless, the original definition of the term stress, as asserted by Selye (1978), who coined the term, is simply a "nonspecific response of the body to any demand" (p. 74) and was not intended to encompass only harmful stimuli.

When exploring the nuances of the stress response, Selye (1978) distinguished between two forms of stress: distress ("bad" stress) and eustress ("good" or "euphoric" stress). Edwards and Cooper (1988) extended this distinction by specifying that individuals are characterized by their self-perceptions (perceived state) and what they want to feel in a given situation (desired state). A stress response occurs when there is a discrepancy between perceived and desired states that require individuals to adjust physiologically, provided the discrepancy is considered important. Accordingly, if the existence of a discrepancy between perceived state and desired state is important to an individual, distress responses mark a negative discrepancy between an individual's perceived and desired states, while eustress responses indicate a positive discrepancy.

Eustress in Relationships

The focus on discrepancies is important to note because of the vital role close relationships play in individuals' lives. Humans experience a fundamental need to belong (Baumeister & Leary, 1995) that leads them to form close relationships which become very meaningful and important (Kelley, 1979). When developing a romantic relationship specifically, individuals may shift toward more-desired (or less-desired) states based on their perceptions. For instance, if Jack wants to enter into a committed relationship with someone, when he meets Jill and they fall in love his perceived happiness may be greater than his original desired happiness, and thus his body will exhibit eustress responses such as elevated heart rate or changes in hormone levels provided that the positive discrepancy between his perceptions and desires is important to him. Put another way, his positive subjective and affective relationship experiences may produce physiological variation.

Eustress in romantic relationships typically begins when forming a new relationship and falling in love, and can continue into the process of becoming more committed and intimate within the relationship (Loving & Wright, in press). Relationships are associated with reward and closeness, which are naturally linked to bodily systems. It may be that the experience of love and intimacy within relationships is stimulating and energizes individuals in a way that only occurs when thinking of or interacting with their romantic partner. To be sure, recent work has demonstrated support for eustress processes in romantic relationships by establishing how love may be physiologically beneficial.

The Physiology of Love

The experience of love can include heightened emotionality, desire for closeness, and euphoria. Neurologically, love involves the motivation, reward, and emotion systems of the brain associated with dopamine (e.g., anterior cingulate cortex, ventral tegmental area, anteromedial caudate area). Activation of these areas allows people to focus on a specific individual (i.e., the romantic partner) and process emotion and other factors appropriately (Aron et al., 2005; Bartels & Zeki, 2000). The activation of physiological response and brain activity, moreover, seem to be unique to romantic partners; these same areas do not react when thinking about or viewing a picture of a friend.

Despite the implications of such intriguing findings, researchers have only recently begun to study love in romantic relationships and its effects on cognitive and physiological response more deeply. In particular, recent research has found that the experience of love can be linked to two major bodily systems that yield specific changes in catecholamines and other hormones: the sympathetic-adrenal-medullary (SAM) system and the hypothalamic-pituitary-adrenal (HPA) axis.

SAM System

Briefly, the SAM system is a major component of the neuroendocrine system and controls reactions to stress and the "fight-or-flight" response (Cannon, 1932). Cannon proposed that in circumstances of acute short-term stress, organisms have a need to mobilize bodily energy to cope and maintain basic functioning. Therefore, activation of the SAM system results in increases in catecholamines, hormones that can facilitate physical and mental activity, such as epinephrine, norepinephrine, and dopamine (Esler et al., 1990). These catecholamines can be rapidly metabolized to regulate physiological responses to stress.

Norepinephrine (also called noradrenaline) in particular has become a recent focus of study in the romantic relationship literature. Synthesized from dopamine or produced on its own from the adrenal glands, norepinephrine has been associated with attraction, courtship behavior, and love (Fisher, 1998). High levels of norepinephrine *tend to increase attention and memory for new stimuli (Griffin & Taylor, 1995; Posner &* Petersen, 1990) and produce feelings of alertness, exhilaration and vitality (Coull, 1998;

Robbins, 1984). These phenomena are also characteristic of the experience of love, such that norepinephrine can stimulate sympathetic nervous activity (e.g., increased heart rate, trembling) that is associated with being near or thinking about a current romantic partner, leading to greater feelings of euphoria and increased attention to that individual specifically (Hatfield & Sprecher, 1986; Tennov, 1979).

Norepinephrine also has a unique relationship with glucose such that it exerts a hyperglycemic effect; that is, it stimulates glycogenolysis, the process of releasing glucose from energy stores in the liver and fatty tissue in human and non-human animals (Gerich, Cryer, & Rizza, 1980; Leibowitz, Sladek, Spencer, & Tempel, 1988). The influence of norepinephrine on glucose increase is temporary, however, and takes place within minutes, with glucose levels peaking approximately ten minutes after exposure to stress (Dinan, 2004). Interestingly, there is currently little evidence that glycogenolysis regulates glucose release and production under normal conditions; rather, it only seems to come into play during times of acute stress. Based on recent research relating love to catecholamines, it may be the case that partner reflection can activate SAM system activity to yield augmented glucose levels, and that this effect may be sustained over time by subsequent HPA axis activation.

HPA Axis

The HPA axis is another part of the neuroendocrine system responsible for stress response and the regulation of a number of bodily processes, such as immune system functioning, mood and emotions, and energy storage and use. Activation of this axis typically mediates long-term stress, as opposed to the short-term stress associated with the SAM system; nonetheless, there is research that demonstrates that the HPA axis can work in conjunction with SAM system activation to sustain and modify stress responses (Adam & Epel, 2007). HPA axis activation is often marked by the secretion of the steroid hormone cortisol (Lovallo, 2005; Selye, 1978), and has recently been the subject of empirical investigation in the realm of relationships research.

The experience of love in romantic relationships has been shown to be characterized by specific hormone changes activated by the HPA axis. For example, Marazziti and Canale (2004) found that, in general, feelings of love are linked to higher overall levels of cortisol. This higher cortisol may reflect arousal and euphoria, and in the case of the experience of love in particular, eustress response. Love in romantic relationships has also been shown to impact levels of nerve growth factor (NGF), a neurotrophin associated with the development and maintenance of sympathetic and sensory neurons (Emanuele et al., 2006). And although some hormonal variation seems to taper off after relationships become more established (i.e., greater than 12 months in length), it seems that the distinct cortisol responses may progress into long-term relationships.

Notably, the hormonal variations associated with love are seen across all individuals. In one of the first experimental studies of the hormonal consequences of love, Loving and colleagues (2009) asked participants classified as high vs. low "relationship thinkers," individuals who think often about all aspects of their partner and relationship, to reflect deeply on either a friend or their current romantic partner using a guided imagery exercise. Following this exercise, both high and low relationship thinkers who reflected on their romantic partner experienced greater short-term cortisol reactivity relative to individuals who reflected on a friend, and the long-term response was particularly strong for high relationship thinkers.

This research provides support for eustress in relationships by demonstrating that positive partner reflection may be arousing and able to yield a bodily reaction. However, the experience of love may have further physiological and behavioral benefits. It is known that cortisol can impact certain metabolic processes (e.g., glucose production), and thus it may be that partner reflection can provide a means to elicit such responses. It has been widely established that cortisol has a relationship to glucose in both human and non-human animals by enhancing gluconeogenesis, the metabolic process of generating glucose from non-carbohydrate substrates (De Feo et al., 1989; Khani & Tayek, 2001; Lecavalier, Bolli, Cryer, & Gerich, 1989; Mosher, Young, & Munck, 1971).

In short, gluconeogenesis takes places mainly in the liver and converts pyruvic acid and other molecules to glucose-6-phosphate, which then transforms into free glucose that can enter the bloodstream to be used by the brain, muscles, or other body tissue. In humans, gluconeogenesis occurs regularly throughout the day at intervals to aid in the maintenance of normal blood glucose levels, and after inducing or experiencing a spike in cortisol, its effects on glucose can be observed in the blood approximately 15-25 minutes later (Hallahan, Young, & Munck, 1973; Munck, 1968).

To sum up, recent research on the physiological consequences of experiencing love has demonstrated that partner reflection can lead to acute bodily responses of catecholamines and other hormones, specifically norepinephrine and cortisol. Because both norepinephrine and cortisol have been shown to increase glucose in the bloodstream, it is reasonable to suggest that partner reflection may yield increases in glucose. This extra glucose may serve as valuable energy usable by the body to facilitate behavioral outcomes. In other words, if partner reflection in particular leads to a physiological eustress response in the form of glucose, it may be the case that this energy may act as a buffer for difficult and depleting tasks.

Self-Regulation

Self-regulation, broadly, is the ability to override impulses and modify behavior. When an individual chooses to, for example, stay in on a Saturday night instead of going out with friends, or abstain from eating an ice cream sundae to reach long-term dieting goals, self-regulatory resources are exerted. In a laboratory setting, self-regulation is exercised when performing tasks such as the Stroop color-naming task (Govorun & Payne, 2006), when suppressing emotion or aggression (DeWall, Baumeister, Stillman, & Gailliot, 2007), and also during stressful social interactions (Finkel et al., 2006).

Ego Depletion

According to the strength model of self-regulation, the ability to effectively self-regulate is thought to depend on limited psychological resources (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Baumeister, Vohs, & Tice, 2007). In other words, self-regulatory capacity acts like a muscle and can become fatigued with use, such that when individuals perform a task that demands self-regulation, their overall capacity is temporarily depleted (a state called ego depletion) and their performance suffers on subsequent tasks that also require self-regulation (Muraven & Baumeister, 2000; Vohs & Heatherton, 2000). Ego depletion has been linked to a number of deleterious outcomes; for example, compared to non-depleted individuals, depleted individuals tend to display impaired logic and reasoning (Schmeichel, Vohs, & Baumeister, 2003), persist less on difficult tasks (Vohs, Baumeister, & Ciarocco, 2005), exhibit less helping behavior (DeWall, Baumeister, Gailliot, & Maner, 2008) and be less forgiving of romantic transgressions (Finkel & Campbell, 2001).

Countering Ego Depletion

Although ego depletion can have negative effects on cognition and behavior, these effects can be counteracted through a number of means. For example, Tice and colleagues (2007) showed that inducing positive affect following ego depletion through humor or gifts restored the self-regulatory capacity of individuals for a subsequent task. In particular, depleted individuals who experienced positive affect were more likely to persist at a difficult task, were able to maintain a strenuous handgrip grasp longer, and drank more of a nasty-tasting beverage relative to depleted individuals who experienced neutral or negative affect. The potentially harmful outcomes associated with ego depletion can also be counteracted through appropriate motivation and incentives (Baumeister & Vohs, 2007), implementation intentions in the form of "if…then" statements (Webb & Sheeran, 2003), and affirming values that are important to the self (Schmeichel & Vohs, 2009).

Feelings of autonomy and vitality are two additional elements that have been shown to counteract ego depletion (Muraven, Gagné, & Rosman, 2008). Specifically, these researchers found that individuals whose autonomy was supported during a depleting task exhibited better self-regulatory capacity on a later task compared to those whose autonomy was suppressed (e.g., through time pressure), and this relationship was mediated by subjective vitality. In other words, subjective feelings of alertness and energy seem to allow individuals to better exert self-regulatory resources in subsequent tasks. As thinking about a romantic partner may be energizing, it is reasonable to suggest that partner reflection may increase such internal experiences of vitality at both a physiological and psychological level.

Prior research has also demonstrated that close positive relationships may bolster the self in the face of depleting situations. For example, Kumashiro and Sedikides (2005) gave participants negative false feedback about their performance on a difficult and important intellectual task after they had reflected on a close positive, close negative, or neutral relationship. Participants were then given a chance to learn more about the task they had presumably failed (i.e., liability-focused information), and those who had reflected on a close positive relationship in particular were more receptive to additional liability-focused information compared to any other condition. To be sure, it seems that close relationships may act as a buffer for potentially negative circumstances and allow individuals to overcome distress.

The Physiology of Self-Regulation

The original theory of self-regulation purported that the limited resources needed for self-regulation were psychological in nature. However, recent work has demonstrated that the process of self-regulation is not just dependent on ambiguous "psychological resources," but may more concretely depend on glucose as an important energy source (Gailliot & Baumeister, 2007; Gailliot et al., 2007). In a series of nine studies, Gailliot and colleagues (2007) induced ego depletion in a variety of ways, including difficult cognitive or attention-control tasks, stressful interaction, and experience of emotion. The authors found consistently that individuals who were depleted experienced a physical decrease of glucose in the bloodstream relative to non-depleted individuals. Moreover, Gailliot et al. found that, following depletion, replenishing glucose stores by a glucose-containing beverage led depleted participants to perform just as well on a task as non-depleted participants.

This body of literature suggests that self-regulation has both physiological and psychological components. It may be that energy from partner reflection may increase feelings of vitality to afford better task performance even in a state of ego depletion, and that this energy may moreover bolster the self against the deleterious effects of ego depletion.

The Present Research

In sum, the question of how partner reflection may yield physical energy and affect self-regulatory ability has yet to be explored. The present study was therefore designed to examine whether and how partner reflection may elicit a eustress response to influence blood glucose levels, act as a buffer for self-regulatory depletion, and impact subsequent task performance. An experimental design was implemented that allowed for examination of both change in glucose levels as well as the trajectory of glucose over time for individuals who thought about their morning routine (non-close relationship condition), a friend, or their current romantic partner. Furthermore, to assure that any physiological responses were eustress in nature, positive affect was assessed. Finally, a versatile and previously validated behavioral task was utilized to examine both performance and persistence following depletion of self-regulatory resources.

Hypothesis 1. The experience of love has been linked to increased levels of norepinephrine, and partner reflection specifically has been shown to result in augmented cortisol reactivity. It is known that both norepinephrine and cortisol can increase glucose by releasing it from energy stores or stimulating its synthesis, respectively. Therefore a main effect of reflection condition was predicted such that, relative to baseline, glucose levels would be higher for individuals who reflected about their romantic partner. Because these eustress responses seem to be romantic partner-specific and not simply close relationship-specific (Aron et al., 2005; Loving et al., 2009), no change or a decrease in glucose levels was predicted for participants who reflected on their morning routine or a friend.

Moreover, reflection condition was expected to interact with time to influence the trajectory of glucose response. That is, norepinephrine should yield an initial glucose increase for individuals who reflected about their romantic partner, and cortisol should sustain that increase or add to it, while this should not be the case for individuals in the routine and friend conditions. In other words, the trajectory of glucose over time for individuals in the partner condition should be positive, and the trajectory for those in the routine and friend conditions should be negative.

Hypothesis 2. Because love and partner reflection are thought to be positive relationship processes that elicit eustress responses (Loving & Wright, in press), and individuals experiencing love are more affected subjectively by relationship stimuli (Kim & Hatfield, 2004), positive affect was expected to be correlated with glucose response for individuals in the partner condition, but not those in the routine or friend conditions (no correlations were expected for these two groups based on the same reasoning behind Hypothesis 1). This hypothesis essentially served as a manipulation check to determine if physiological changes were experienced as distress vs. eustress.

Hypothesis 3. Prior research has demonstrated that exercising self-regulation can deplete glucose in the blood (Gailliot et al., 2007). A main effect of depletion condition was therefore predicted such that individuals who engaged in a depleting task would experience a decrease in glucose levels following the task compared to individuals who engaged in a control task.

Moreover, self-regulatory depletion was expected to interact with reflection such that non-depleted individuals in the routine and friend conditions were expected to follow a natural decline in glucose over time, but individuals in the routine and friend conditions that depleted their regulatory resources were expected to have the lowest final glucose levels. Conversely, non-depleted individuals in the partner condition were expected to exhibit the highest final glucose levels, and furthermore, the physical energy from partner reflection in particular was expected to act as a buffer for self-regulatory depletion such that individuals in the partner condition would still exhibit higher final glucose levels compared to those in the routine or friend conditions even when they depleted regulatory resources.

Hypothesis 4. Lastly, as self-regulatory depletion has been greatly associated with poorer subsequent performance and persistence (e.g. Baumeister et al., 1998; Vohs et al., 2005), individuals in the routine and friend conditions who engaged in a depleting task were expected to perform worse and persist less on a subsequent task. However, because norepinephrine has been associated with enhanced attention and alertness (e.g., Posner & Petersen, 1990), and eustress response has been operationally defined in the past as the optimal amount of arousal needed to maximize task performance (Gibbons, Dempster, & Moutray, 2008), it was expected that depleted individuals in the partner condition would not exhibit the same detriment in subsequent task performance as other depleted participants.

Method

Participants and Design

97 individuals (28 male, 69 female) were recruited from the University of Western Ontario and surrounding London area. Individuals were eligible for participation if they were currently involved in a relationship of at least one month and did not have a medical condition related to glucose (e.g., diabetes, hypoglycemia). Four participants were excluded from the study, two because they did not meet eligibility requirements (e.g., were single or had a medical condition related to glucose), and two because they failed to follow directions prior to and during the study and their data were unusable. A final sample of 93 participants (27 male, 66 female) was therefore retained.

Participants were between 18 and 37 years of age ($M = 21.95$, $SD = 3.70$) and were currently involved in relationships lasting between 1 and 120 months ($M = 22.37$, $SD = 22.65$). Approximately 4.3% were involved in non-exclusive dating relationships, 88.2% were in exclusive dating relationships, 4.3% were common-law, 1.1% were engaged, and 2.2% were married. Individuals received either course credit or $15.00 compensation for their participation.

A 3 × 2 × 3 (Reflection [routine, friend, partner] × Self-Regulatory Capacity [no depletion, depletion] × Glucose Measurement [baseline, post-reflection, post-depletion]) mixed model design was implemented. Reflection and depletion conditions were between-subjects, while glucose measurement was within-subjects repeated measures.

Participants were randomly assigned to one of six between-subjects experimental conditions.

Materials and Measures

Blood glucose levels. Blood glucose was measured (mg/dL) using single-use disposable lancets and an Accu-Check® meter, consistent with prior research (e.g., Gailliot et al., 2007). A new lancet was used for each collection of blood. Blood samples were collected three times: initially (baseline), following the guided imagery exercise (post-reflection), and following the depletion manipulation (post-depletion).

Guided imagery exercise. Participants were asked to think deeply about their morning routine, a non-romantic friend, or their current romantic partner using a detailed script (see Appendix A). Specifically, the exercise was designed for relaxation and imagination; participants envisioned their morning routine, friend, or partner in detail, recalled specific things and events, and so on. Friend and partner scripts were taken from Loving et al. (2009) and have been shown to yield physiological and behavioral outcomes. The routine script was developed by the present author to serve as a neutral, non-relationship comparison.

Positive affect measure. As a measure of mood participants completed the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988; see Appendix B). This scale is comprised of 20 items, 10 items of which measured positive affect (e.g., "I feel excited") and 10 of which measured negative affect (e.g., "I feel distressed"). Individuals rated their current feelings on a scale of 1 (*very slightly or not at all*) to 5 (*extremely*), $\alpha = .91$ for positive affect, $\alpha = .88$ for negative affect. For this study all items associated with negative affect were subtracted from the items associated with positive affect to create a general index of affect. A score of zero indicated neutral affect, an overall positive score indicated more positive affect than negative affect, and an overall negative score indicated the reverse.

Ego depletion manipulation. To manipulate self-regulatory capacity, participants were given a sheet of unrelated text and instructed to cross out all instances of the letter "e" (see Appendix C). Those in the no depletion condition were instructed to cross out every "e," whereas individuals in the depletion condition were told to cross out every "e" except those located directly next to or one letter away from another vowel (e.g., the "e" in "vowel" would not be crossed out). Participants in the depletion condition therefore had to keep track of the rules as they worked through the task and override their impulse to cross out every "e." This paradigm was taken from Baumeister et al. (1998), who showed that individuals who received the depletion instructions were significantly more mentally exhausted than those who received the control instructions.

Performance/persistence task. In order to measure the behavioral effects of reflection and depletion, participants completed an anagram task taken from Gilhooly and Johnson (1978; see Appendix D). Participants were given 80 5-letter anagrams and asked to rearrange the letters into an English word (e.g., IPTLU → TULIP). All anagrams had one correct solution, and participants were asked to work on the task until they completed all anagrams or until they no longer wanted to work on the task. This task required self-regulation as it assessed the ability to override the impulse to quit and instead persist at the task. Prior work (e.g., Vohs, Baumeister, & Ciarocco, 2005; Vohs & Heatherton, 2000) has demonstrated that depleted individuals persist less on subsequent self-regulation tasks compared to non-depleted individuals.

Procedure

Participants were instructed not to eat or drink anything other than water for three hours prior to their appointment to allow glucose levels to stabilize. Participants arrived at the lab and first completed a brief demographic questionnaire, after which the first glucose sample (baseline) was taken. Next, participants answered several questionnaires about themselves, their partner, and their relationship (e.g., attachment style, passionate love, relationship satisfaction)[1]. They were then given a five-minute break to relax.

Participants then underwent the guided imagery exercise in which they reflected about their morning routine, a non-romantic friend, or their current romantic partner. Following reflection, participants watched a video containing neutral imagery of various nature scenes from the Planet Earth television series for ten minutes and then provided their second glucose sample (post-reflection). They then filled out the measure of positive affect.

Next, participants completed the "e" task for ten minutes, after which the third and final glucose sample (post-depletion) was taken (approximately 25 minutes following the guided imagery exercise). Participants were next given a booklet of 80 5-letter anagrams and were instructed to work on the task until they had solved all the anagrams, or until they decided to stop working. Individuals were surreptitiously timed to see how long they persisted at the task, and were allowed to work until they decided to stop or they hit a 20-minute ceiling. Lastly, participants completed a final questionnaire that asked about their perceptions of the different tasks and probed for hypothesis suspicion.

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[1] These measures were analyzed as possible moderating variables in the relationship between experimental condition and physiological and behavioral outcomes, but no significant effects emerged for any of the conditions, all *ps* > .15.

Participants were then fully debriefed and allowed to ask questions, compensated, and dismissed. The entire study took approximately an hour and a half to complete.

Results

Covariate Analyses

The significance of a number of potential covariates, including health behaviors known to affect physiological processes (e.g., age, birth control use, time of waking, alcohol consumption), in addition to relationship length, was assessed prior to final glucose analyses. Specifically, these variables were initially included as predictors in the models testing the study hypotheses; however, no covariates were found to be significant control variables (all *p*s > .20) and therefore they were removed from the final models.

Glucose Change

Glucose was measured in mg/dL, and a multiple regression approach was used to test the study hypotheses. For all regression analyses, two dummy codes were created to represent the three reflection conditions. Specifically, the routine condition was given values of 0 on both dummy codes, whereas the friend condition was given values of 1 and 0 on each dummy variable, respectively, and the partner condition was given values of 0 and 1 on each dummy variable, respectively. The routine condition thus served as the comparison group for the friend and partner conditions. When noted, the values for the dummy codes were reset to allow for comparisons between the friend and partner conditions.

Post-reflection glucose. In this analysis, post-reflection glucose levels served as the outcome variable and baseline glucose was entered as a predictor in order to assess possible changes in glucose from baseline to post-reflection. As seen in Figure 1, relative to individuals in the routine condition (*M* = -1.10, *SD* = 6.64), individuals in the partner condition (*M* = 3.03, *SD* = 9.53) exhibited increased glucose, controlling for baseline glucose, $b = 4.13$, $t(89) = 1.94$, $p = .055$. Post-reflection glucose for individuals in the friend condition (*M* = 0.38, *SD* = 8.42) did not significantly differ from those in the routine or partner conditions, $b = -1.48$, $t(89) = -0.69$, $p > .40$ and $b = 2.65$, $t(89) = 1.26$, $p > .20$, respectively.

Depletion manipulation. In this analysis, post-depletion glucose levels served as the outcome variable and post-reflection glucose was entered as a predictor in order to assess possible changes in glucose attributable to the depletion manipulation. The dummy codes for the reflection conditions, in addition to a dummy code value of -1 for the no depletion condition and a dummy code value of 1 for the depletion condition were also entered as predictors. The interactions between the reflection conditions and the depletion condition dummy codes were entered in the model as well. Results revealed only a main effect of depletion condition, such that individuals who completed the depleting "e" task (*M* = -3.64, *SD* = 7.32) exhibited lower post-depletion glucose compared to individuals who completed the non-depleting "e" task (*M* = -0.94, *SD* = 5.68), controlling for post-reflection glucose, $b = -1.13$, $t(88) = -1.99$, $p = .05$, see Figure 2.

Final glucose. In this analysis, post-depletion glucose levels served as the outcome variable and baseline glucose was entered as a predictor in order to assess possible changes in glucose from the beginning to the end of study participation. The same set of predictor variables described in prior analyses was included in this model. Contrary to hypotheses, no main or interactive effects emerged for the depletion condition, all *p*s > .45. In other words, self-regulatory depletion did not impact final glucose levels for any of the reflection conditions. Compared to individuals in the routine condition ($M = -1.09$, $SD = 6.01$), however, individuals in the partner condition ($M = 3.26$, $SD = 8.08$) exhibited increased glucose, controlling for baseline glucose, $b = 4.35$, $t(88) = 2.46$, $p < .02$. Moreover, relative to individuals in the friend condition ($M = -0.75$, $SD = 6.28$), individuals in the partner condition exhibited increased glucose, $b = 4.01$, $t(88) = 2.29$, $p < .03$. Post-reflection glucose for individuals in the friend condition did not significantly differ from those in the routine condition, $b = -0.34$, $t(88) = -0.19$, $p > .80$. These results are represented graphically in Figure 3.

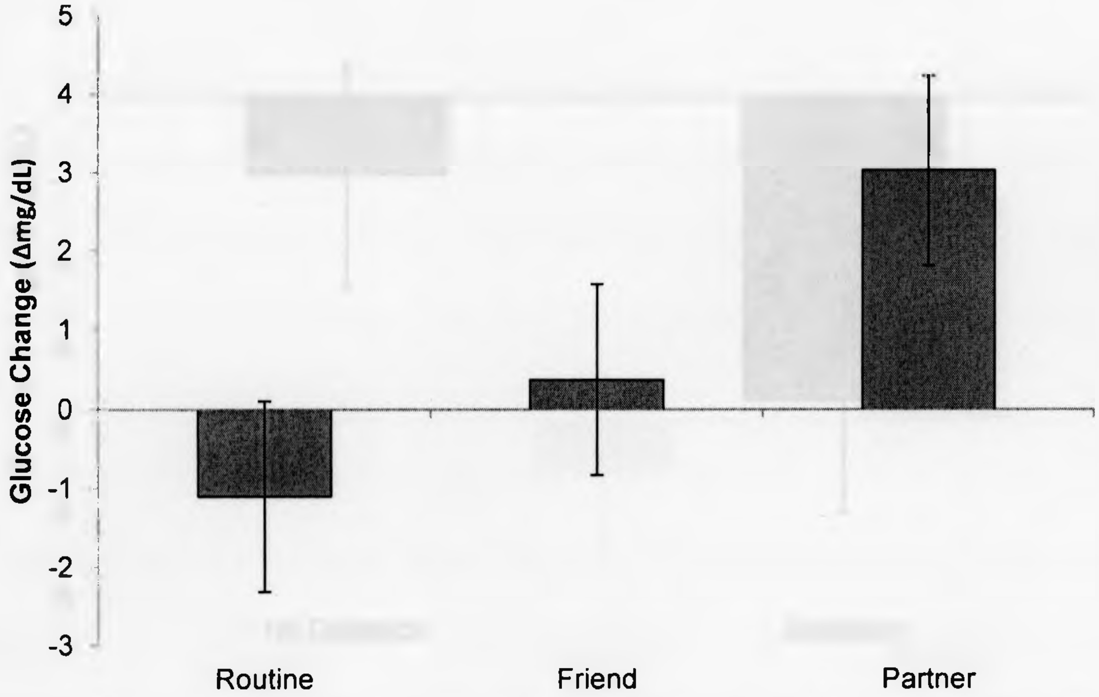

Figure 1. Mean difference values (mg/dL) representing post-reflection glucose change from baseline glucose as a function of reflection condition. Error bars represent standard error.

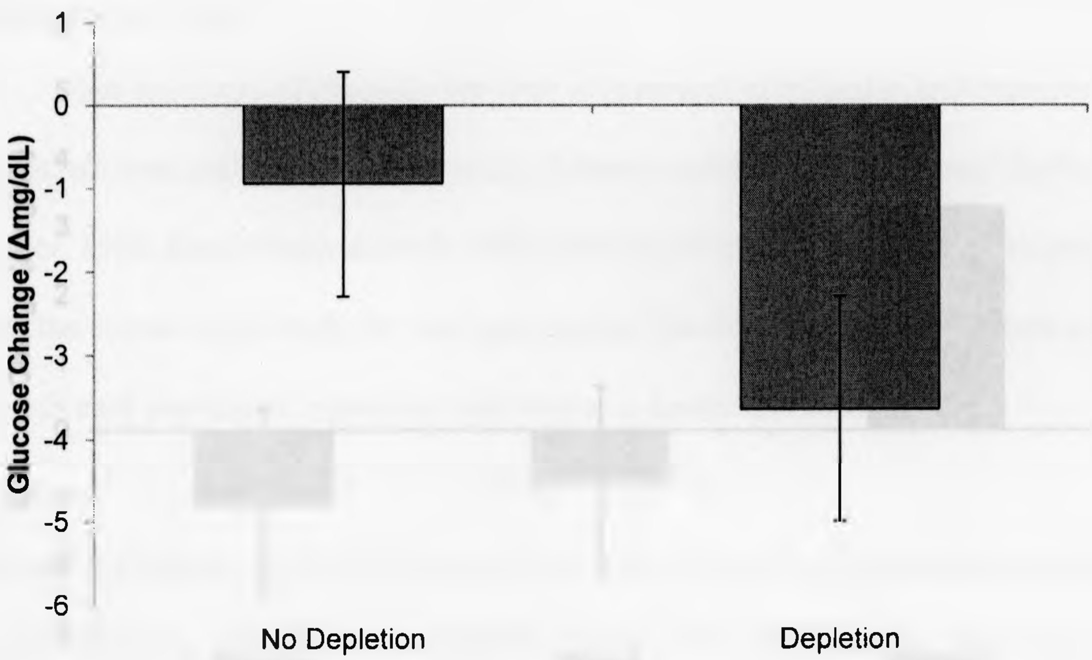

Figure 2. Mean difference values (mg/dL) representing post-depletion glucose change from post-reflection glucose as a function of depletion condition. Error bars represent standard error.

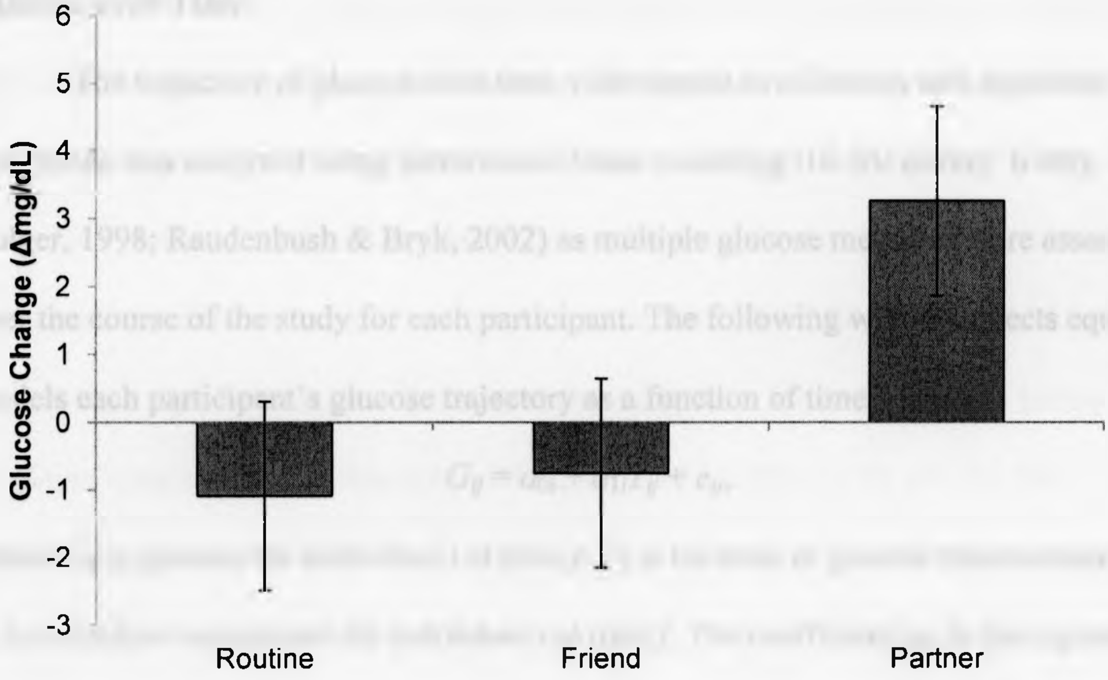

Figure 3. Mean difference values (mg/dL) representing post-depletion glucose change from baseline glucose as a function of reflection condition. Error bars represent standard error.

Glucose over Time

The trajectory of glucose over time with respect to reflection and depletion conditions was analyzed using hierarchical linear modeling (HLM; Kenny, Kashy, & Bolger, 1998; Raudenbush & Bryk, 2002) as multiple glucose measures were assessed over the course of the study for each participant. The following within-subjects equation models each participant's glucose trajectory as a function of time:

$$G_{ij} = a_{0i} + a_{1i}T_{ij} + e_{ij},$$

where G_{ij} is glucose for individual i at time j, T_{ij} is the time of glucose measurement, and e_{ij} is a residual component for individual i at time j. The coefficient a_{0i} is the regression intercept for individual i and represents baseline glucose given how time was coded (i.e., 0 = *baseline*, 1 = *post-reflection*, 2 = *post-depletion*).

The between-subjects equations treat the intercepts and slopes from the within-subjects analyses as outcome variables in two regressions. For these equations, the coefficients obtained from the within-subjects analyses are assumed to be a function of reflection and depletion conditions:

$$a_{0i} = b_0 + b_1R_{1i} + b_2R_{2i} + b_3D_i + f_i;$$

$$a_{1i} = c_0 + c_1R_{1i} + c_2R_{2i} + c_3D_i + g_i.$$

The first equation treats the first-step intercepts as a function of reflection and depletion conditions with error (f_i), and the second equation treats the first-step slopes as a function of reflection and depletion conditions with error (g_i). Using dummy codes similar to those used in the regression analyses for glucose change, the first equation predicts the average baseline glucose as a function of being in the friend (R_{1i}) or partner (R_{2i}) condition, compared to the routine condition, as well as being in the no depletion or depletion condition (D_i). The second equation determines if the trajectory of glucose over time differs for participants in the friend or partner condition, compared to the routine condition, in addition to those in the no depletion and depletion conditions[2].

As predicted, a significant interaction with time was revealed for individuals in the partner condition compared to the routine condition, $b = 2.20$, $t(183) = 2.26$, $p < .03$. Moreover, a significant interaction with time emerged for individuals in the partner condition compared to the friend condition, $b = 2.11$, $t(183) = 2.19$, $p < .03$. No interaction with time emerged for individuals in the friend condition compared to the routine condition, $b = -0.09$, $t(183) = -0.09$, $p > .90$. Additionally, interactions between the reflection and depletion conditions were included in the model but, contrary to expectations, no effects emerged, all *p*s > .25.

As shown in Figure 4, glucose levels of individuals in the partner condition rose slightly following the guided imagery exercise and remained level through the last glucose sample collected after the depletion manipulation. In contrast, glucose levels of individuals in the routine and friend conditions decreased following the guided imagery exercise and continued to decrease through the last glucose sample. Tests of simple slopes revealed that individuals in the routine and friend conditions indeed exhibited a significant negative trajectory of glucose over time, $b = -1.83$, $t(59) = -3.01$, $p < .01$ and $b = -1.74$, $t(61) = -2.51$, $p < .02$, respectively. However, the simple slope for individuals in the partner condition was not significant, $b = 0.37$, $t(63) = 0.49$, $p > .60$, indicating that glucose levels remained around baseline or slightly above baseline for the duration of the study. In other words, individuals who thought about their current romantic partner

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[2] Possible non-linear variables ($time^2$) were also investigated initially, but no meaningful effects emerged (all *p*s > .25) and therefore those predictors and their interactions were removed from final models.

seemed to experience increases in glucose that buffered them against a natural short-term and long-term decline in glucose over time (thus yielding a sustained trajectory) that would be expected given the nature of the study and tasks involved, compared to individuals who reflected on their morning routine or a friend, whose glucose levels reflected the predicted decline over time.

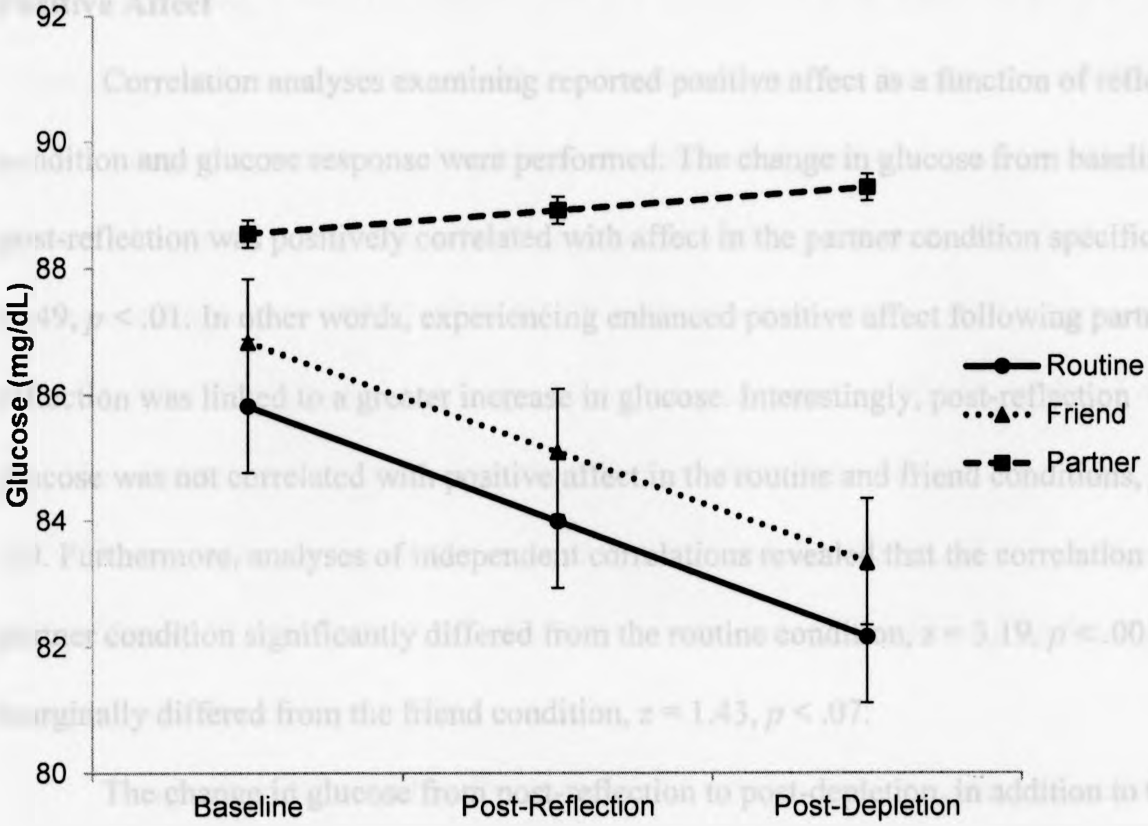

Figure 4. Trajectory of glucose levels (mg/dL) over time as a function of reflection condition. Error bars represent standard error.

Positive Affect

Correlation analyses examining reported positive affect as a function of reflection condition and glucose response were performed. The change in glucose from baseline to post-reflection was positively correlated with affect in the partner condition specifically, $r = .49$, $p < .01$. In other words, experiencing enhanced positive affect following partner reflection was linked to a greater increase in glucose. Interestingly, post-reflection glucose was not correlated with positive affect in the routine and friend conditions, *p*s > .20. Furthermore, analyses of independent correlations revealed that the correlation in the partner condition significantly differed from the routine condition, $z = 3.19$, $p < .001$, and marginally differed from the friend condition, $z = 1.43$, $p < .07$.

The change in glucose from post-reflection to post-depletion, in addition to the change in glucose from baseline to post-depletion, was not significantly correlated with positive affect for any reflection conditions, all *p*s > .15.

Subsequent Task Performance

Anagram performance. Anagram performance was analyzed with three dependent measures: number completed, persistence (amount of time spent on the task), and efficiency (number of anagrams completed controlling for time spent on the task). First, the number of anagrams completed overall was assessed. As seen in Figure 5, relative to individuals in the routine condition ($M = 26.90$, $SD = 15.69$), those in the partner condition ($M = 36.28$, $SD = 19.36$) completed significantly more anagrams, $b = 9.38$, $t(89) = 2.06$, $p < .05$. The number of anagrams completed by individuals in the friend condition ($M = 32.11$, $SD = 18.17$) did not differ from those in the control or partner conditions, $b = -5.21$, $t(89) = -1.13$, $p > .25$ and $b = 4.18$, $t(89) = 0.92$, $p > .35$, respectively, and no interaction of reflection and depletion was found, all $ps > .40$.

Anagram persistence. Persistence was measured in seconds spent working on the task. As shown in Figure 6, a trend emerged such that, relative to individuals in the routine condition ($M = 908.37$, $SD = 302.05$), those in the partner condition ($M = 1013.84$, $SD = 231.26$) persisted longer on the anagram task, $b = 105.48$, $t(89) = 1.47$, $p < .15$. The persistence of individuals in the friend condition ($M = 986.98$, $SD = 307.24$) did not differ from those in the control or partner conditions, $b = -78.61$, $t(89) = -1.08$, $p > .25$ and $b = 26.87$, $t(89) = 0.38$, $p > .70$, respectively, and no interaction of reflection and depletion was found, all $ps > .30$.

Anagram efficiency. Finally, to assess the efficiency of anagram performance, the number of completed anagrams served as the outcome variable and the time spent on the task (i.e., persistence) was statistically controlled for. A marginally significant main effect revealed that, relative to individuals in the routine condition ($M = 9.48$, $SD = 14.05$), individuals in the partner condition ($M = 16.84$, $SD = 19.82$) completed more anagrams in the same amount of time, $b = 7.36$, $t(88) = 1.66$, $p = .10$. The efficiency of individuals in the friend condition ($M = 13.18$, $SD = 16.47$) did not differ from those in the control or partner conditions, $b = -3.70$, $t(88) = -0.83$, $p > .40$ and $b = 3.66$, $t(88) = 0.84$, $p > .40$, respectively, and no interaction of reflection and depletion was found, all $ps > .20$. Results are presented graphically in Figure 7.

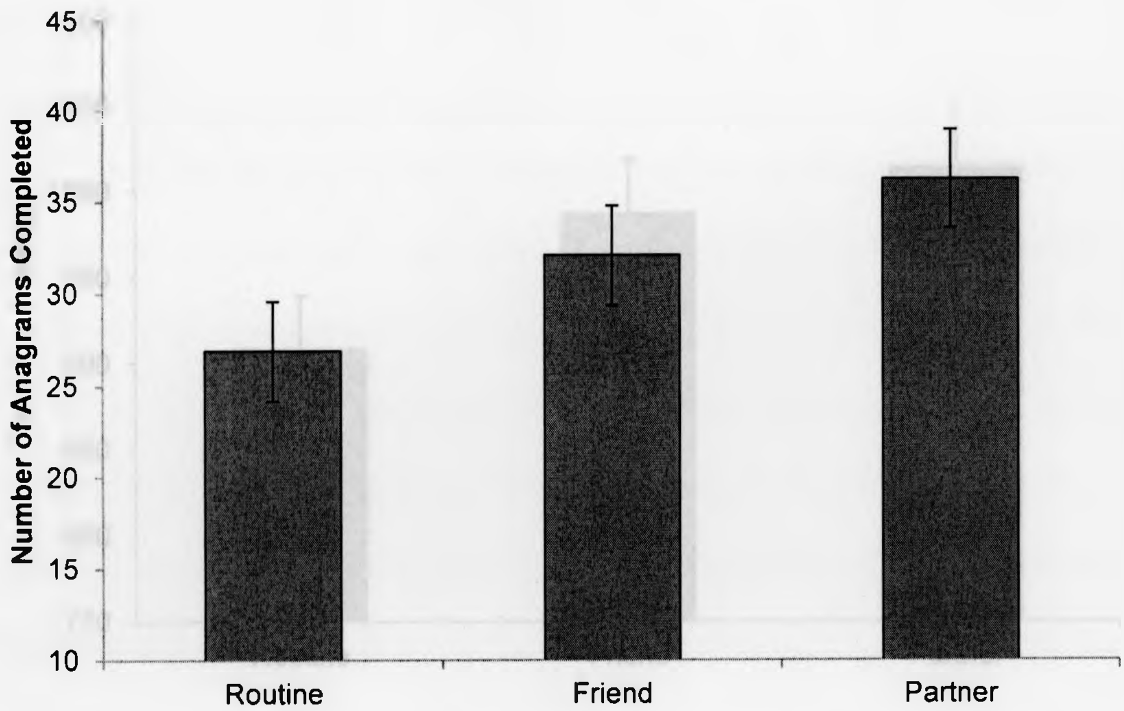

Figure 5. Number of completed anagrams as a function of reflection condition. Error bars represent standard error.

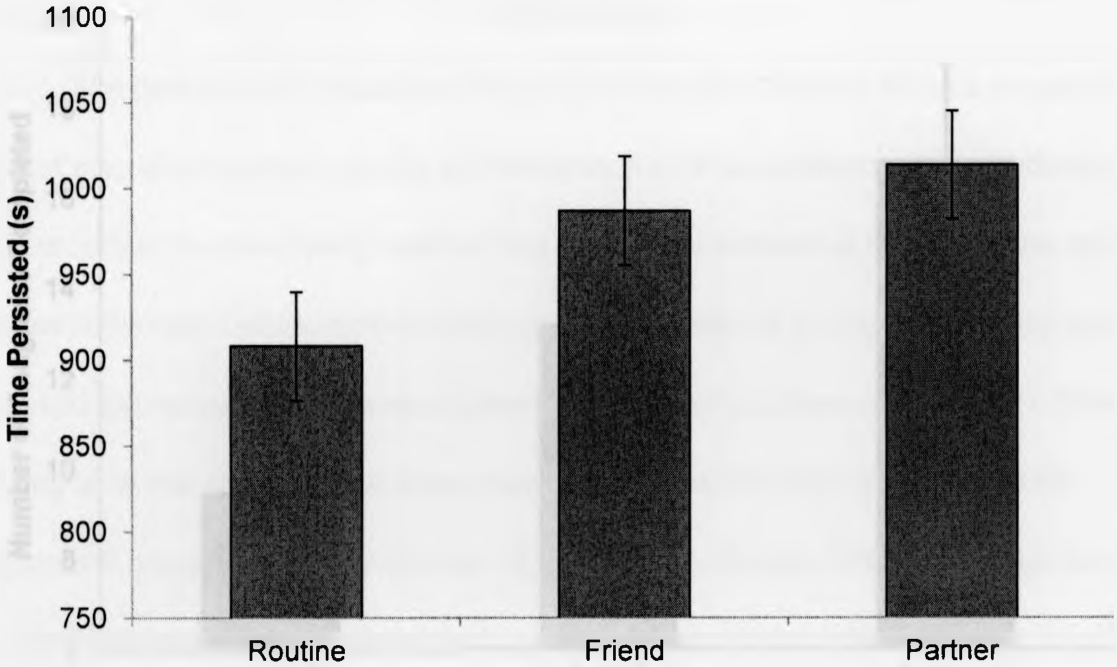

Figure 6. Anagram persistence (s) as a function of reflection condition. Error bars represent standard error.

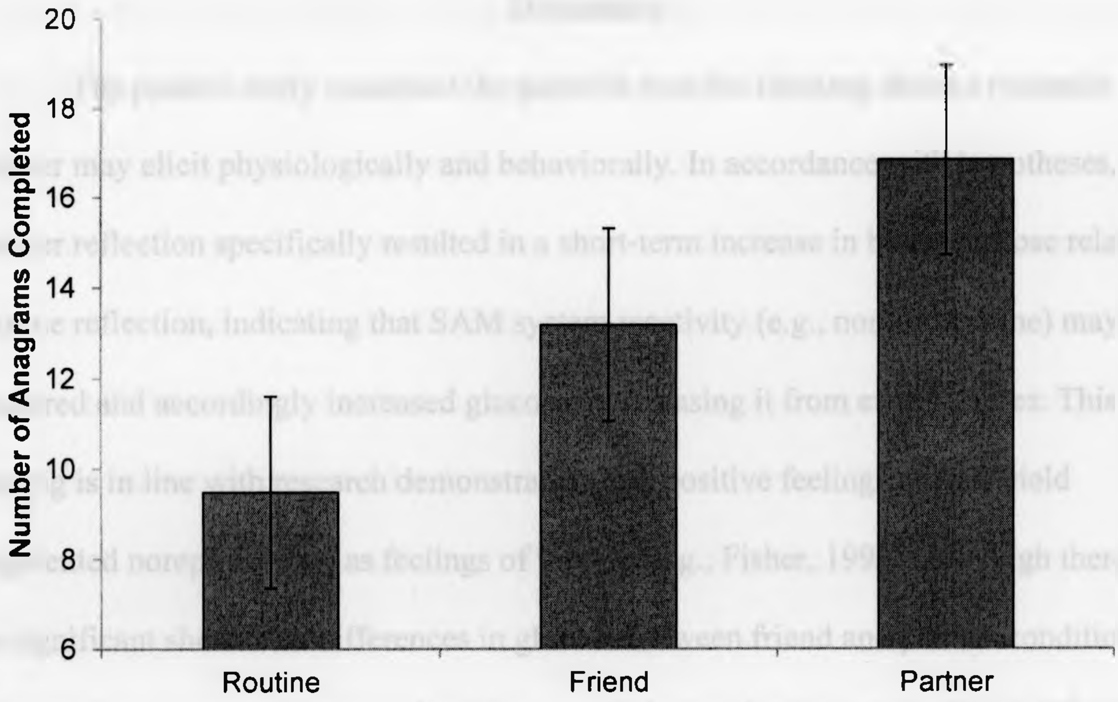

Figure 7. Anagram efficiency (i.e., number of completed anagrams controlling for persistence) as a function of reflection condition. Error bars represent standard error.

Discussion

The present study examined the possible benefits thinking about a romantic partner may elicit physiologically and behaviorally. In accordance with hypotheses, partner reflection specifically resulted in a short-term increase in blood glucose relative to routine reflection, indicating that SAM system reactivity (e.g., norepinephrine) may have occurred and accordingly increased glucose by releasing it from energy stores. This finding is in line with research demonstrating that positive feelings of love yield augmented norepinephrine as feelings of vitality (e.g., Fisher, 1998). Although there were no significant short-term differences in glucose between friend and partner conditions, this may have occurred as a result of the natural decline in glucose for friend reflection taking longer.

Partner reflection (but not routine or friend reflection) additionally resulted in long-term higher levels of glucose that upheld regardless of self-regulatory depletion manipulation, suggesting that thinking about a romantic partner can buffer against depleting stimuli. Moreover, the long-term higher levels of glucose for individuals in the partner condition support the idea that HPA axis activity (e.g., cortisol) may sustain short-term physiological activity that yields physical energy.

Moreover, the examination of glucose over time revealed that, regardless of self-regulatory depletion, partner reflection resulted in a stable trajectory of glucose, while routine and friend reflection yielded a negative trajectory over time. That is, only partner reflection led to higher glucose levels over the course of the hour-and-a-half-long study, whereas routine and friend reflection followed a natural decline over time given that participants completed numerous demanding tasks during the experiment. This result further resonates with established findings that suggest that HPA axis activation can sustain and add to SAM system activity over time (Adam & Epel, 2007).

Also as expected, partner reflection seemed to reflect a eustress response in the body, as the increase in glucose following partner reflection was positively associated with positive affect. Although this relationship between physiological response and positive affect was only correlational in nature such that causation cannot be inferred, the significant correlation occurred only in the partner condition, indicating that the association between positive affect and physiological response seems to be unique to thinking about a romantic partner and not something neutral (i.e., routine) or an alternate close relationship (i.e., friend).

Finally, partner reflection specifically yielded overall trends for better performance on a subsequent task following self-regulatory depletion. Compared to individuals who underwent routine reflection, those who underwent partner reflection completed more 5-letter anagrams and exhibited a tendency to persist longer on the entire anagram task. Moreover, partner reflection led to marginally greater efficiency such that, in the same amount of time, individuals who thought about their romantic partner completed more anagrams than those who thought about their morning routine. This finding demonstrates that partner reflection is energizing for individuals in romantic relationships, and that SAM system and HPA axis stimulation can lead to greater alertness and attention (Posner & Petersen, 1990).

There were no differences in persistence and performance between individuals who thought about their romantic partner and those who thought about a friend, but this may be because friendship still exemplifies a close relationship that may allow for good performance (Jehn & Shah, 1997). However, persistence and performance between individuals in the routine and friend conditions did not differ either, which may speak more to the nature of the task in assessing performance as opposed to the nature of the relationship or event thought about during reflection. In other words, these discrepancies in behavioral results may have come about because the present study did not take individual variation on anagram performance into account.

Contrary to hypotheses, no interaction effects of reflection and depletion conditions emerged. More specifically, although a main effect of depletion was found such that individuals who completed a depleting task exhibited lower glucose levels following the task compared to their non-depleted counterparts (replicating Gailliot et al., 2007), self-regulatory depletion did not impact final glucose levels of individuals across reflection conditions, despite the prediction that final glucose would be especially low for depleted individuals in the routine and friend conditions (but not those in the partner condition). This may have occurred because, although self-regulatory depletion did decrease glucose levels following completion of the "e" task, the amount of glucose lost may not have been meaningful enough across all participants to yield distinguishable differences in the overall trajectory of glucose over time for individuals in all reflection conditions.

Additionally, depletion did not influence task performance or persistence for individuals in any reflection condition, despite the expectation that performance and persistence would be impaired for individuals in the routine and friend conditions (but not those in the partner condition). The lack of behavioral depletion effects may have occurred because the guided imagery manipulation had a stronger influence on individuals than the depletion manipulation. Deep breathing, concentration, and engaging imagination may put individuals in a relaxed mindset that is unaffected by self-regulatory depletion regardless of the physiological decrease in glucose. Furthermore, the depletion manipulation occurred after the reflection manipulation, which may have weakened its behavioral effects. Put another way, one manipulation was nested in another, and the effects associated with the reflection manipulation may have overpowered the depletion manipulation. A fully crossed experimental design may be needed to better understand the potential effects of depletion following guided imagery.

Limitations

An important limitation of the present research is that it did not appropriately take into account the possibility that some individuals are more adept at solving anagrams than others, which has the potential to confound performance results. In the present study there was no baseline measure of anagram-solving ability, and thus there was no way to control for individual differences in performance. Despite these issues, however, individuals in the partner condition did complete more anagrams overall compared to those in the routine condition, which indicates that they felt energized after thinking about their partner and, when given a task, were better able to exert themselves than individuals who thought about their morning routine.

A final concern is that it was argued that the observed increases in glucose within the partner condition resulted from activation of the SAM system and HPA axis, and in particular from augmented levels of norepinephrine and cortisol. Unfortunately, there were no direct measures of SAM system or HPA axis activity in the current study, and thus the present research can only speculate that norepinephrine and cortisol underlie the glucose response exhibited in the partner condition. Follow-up research should examine these additional physiological measures in order to confirm the precise nature of an individual's glucose response to partner reflection.

Implications and Future Directions

One interesting implication of the current findings is that they may provide evidence for the mechanism behind the process by which close relationships may bolster the self against harmful stimuli. For instance, Kumashiro and Sedikides (2005) found that individuals who reflected on a positive close relationship were more willing to face liability-focused information following failure. The authors speculated that positive affect was the reason behind their results, but the current study adds a compelling physiological component that is linked to positive affect. It may be the physiological response to partner reflection, combined with positive affect, allows individuals to better handle future distress or demand. Additional research on how partner reflection may bolster the self would create a richer view of cognitive, emotional, and physiological processes in relationships.

To be sure, the present research promotes understanding of how relationships affect the body and provides support for eustress responses within romantic relationships. Because the current study shows that relationship cognition (i.e., partner reflection) is closely tied to biological bodily responses that are associated with feelings of positive affect, these findings further resonate with the literature on embodied cognition (for reviews see Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Smith & Semin, 2004). Relationships are central aspects of individuals' lives, and with physiological studies in relationships becoming a burgeoning area of research, it may be possible to effectively study cognition and affect in an integrative fashion (Bradbury & Fincham, 1987). Future studies may consider using physiological measures of eustress processes to explain the cognition–affect link.

This study may also contribute to research on short-term health and well-being. More specifically, the role of love in energizing individuals and promoting cognitive capacity has obvious positive implications for relationship health (e.g., development and maintenance of intimacy, longevity) as well as physical and mental health. For example, experiencing love has been linked to decreased feelings of depression, anxiety, and self-consciousness (Traupmann & Hatfield, 1981). Future research could investigate the role of positive partner reflection and positive partner interaction in predicting high vs. low blood pressure, or other health outcomes. Understanding these mechanisms in more depth so that they may be translated into interventions to improve physical and mental health within relationships as well as for the individual is an issue of great importance.

Lastly, future research may wish to examine individual difference variables that may mediate or moderate physiological eustress responses. For example, attachment anxiety is characterized by a fear of rejection and abandonment, and highly anxious individuals tend to experience an augmented physiological stress response in the face of both general (Quirin, Pruessner, & Kuhl, 2008) and relationship-relevant stress (Powers, Pietromonaco, Gunlicks, & Sayer, 2006). These individuals often have a lower threshold for perceiving stress in their relationships and tend to harbor positive and negative emotions about relationship stimuli simultaneously (Mikulincer & Shaver, 2003). It might be expected, therefore, that highly anxious individuals would experience greater and more frequent variation in both distress and eustress responses that fluctuate physiologically in day-to-day interactions.

Concluding Remarks

The growth of research on the physiology of relationships is a vital step in understanding how relationship stimuli affect the body and how this may translate to cognition, emotion, and behavior. Equally essential is the important distinction of distress and eustress responses and their meaning for relationships. The results from the current study present new evidence of how something as simple as thinking about a romantic partner can afford physical and mental energy. This research provides support for eustress processes in romantic relationships, and creates avenues for future exploration of relationship phenomena.

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Appendix A

Guided Imagery Exercise (Loving et al., 2009; Stanton, 2011)

Routine.

Okay, what I want you to do is try to relax and think about your morning routine. I hope that you'll be able to shut out all other thoughts and really focus on your thoughts and feelings about your morning routine and nothing else. To help you do this, I'm going to take you through a brief relaxation exercise. It might seem a little awkward at first, but if you concentrate, you'll be able to stay focused on your routine. As part of the exercise, I'm going to ask you to imagine a range of things about your morning routine. Sometimes I'll ask you to picture things by prompting you with questions. You DO NOT need to respond; just do your best to create a vivid image by using the prompts. Does that make sense?

I want you to start by closing your eyes and clearing your mind. Try not to think about anything else but the sound of my voice and feeling your body relax. You should slowly notice any tensions in your body and just let each of them go. (*PAUSE; count to 3.*) Good, now take a deep breath, inhale (*PAUSE; count to 2*) and exhale (*PAUSE; count to 3*). Feel yourself relax from the top of your head, down your body, all the way to your toes. All of your tension should be draining away. Inhale (*PAUSE; count to 2*) and exhale (*PAUSE; count to 3*). You should now be able to feel the relaxation of your entire body. Inhale (*PAUSE; count to 2*) and exhale again, letting all the air out of your body (*PAUSE; count to 3*). Good, now your mind is cleared and your body is relaxed (*PAUSE; count to 3*). Now I want you to imagine waking up in the morning. (*PAUSE; count to 3.*)

Picture your room and try to visualize all the details about it. (*PAUSE; count to 3.*) Think about the first thing you do when you wake up. What is it? Really try to remember the events of your day and the order in which they tend to occur as accurately as you can. (*PAUSE; count to 5.*)

What is the next thing you do in the morning? (*PAUSE; count to 5.*) Do you typically eat breakfast? If you do, what do you eat? (*PAUSE; count to 3.*) Think about the next part of your daily routine. (*PAUSE; count to 3.*)

Now think about being ready for the day. (*PAUSE; count to 3.*) Picture yourself walking out of the door to your place. What do you notice as soon as you walk out the door? (*PAUSE; count to 3.*) What things do you do after you leave your place? (*PAUSE; count to 5.*)

Think about how you go about your day. (*PAUSE; count to 5.*) The key thing is that all you are thinking about right now is your daily routine. (*PAUSE; count to 5.)*

Now stay focused on all of these thoughts. Take another deep breath, inhale (*PAUSE; count to 2*) and exhale (*PAUSE; count to 3*). Good, you can open your eyes now.

Friend.
Okay, what I want you to do is try to relax and think about your relationship with your friend, ________. I hope that you'll be able to shut out all other thoughts and really focus on your thoughts, feelings, and friendship with ________ and nothing else. To help you do this, I'm going to take you through a brief relaxation exercise. It might seem a little awkward at first, but if you concentrate, you'll be able to stay focused on ________. As part of the exercise, I'm going to ask you to imagine a range of things about your friendship with ________. Sometimes I'll ask you to picture things by prompting you with questions. You DO NOT need to respond; just do your best to create a vivid image of your friend and the two of you by using the prompts. Does that make sense?

I want you to start by closing your eyes and clearing your mind. Try not to think about anything else but the sound of my voice and feeling your body relax. You should slowly notice any tensions in your body and just let each of them go. (*PAUSE; count to 3.*) Good, now take a deep breath, inhale (*PAUSE; count to 2*) and exhale (*PAUSE; count to 3*). Feel yourself relax from the top of your head, down your body, all the way to your toes. All of your tension should be draining away. Inhale (*PAUSE; count to 2*) and exhale (*PAUSE; count to 3*). You should now be able to feel the relaxation of your entire body. Inhale (*PAUSE; count to 2*) and exhale again, letting all the air out of your body (*PAUSE; count to 3*). Good, now your mind is cleared and your body is relaxed (*PAUSE; count to 3*). Now I want you to imagine ________ emerging from the clear space in your mind. (*PAUSE; count to 3.*)

Picture ________'s face and try to visualize all the details about him/her. (*PAUSE; count to 3.*) Think about the first time you met ________. Where were you? What were you doing? Really try to remember the event as accurately as you can. (*PAUSE; count to 5.*)

What were your early impressions about your friendship with ________? (*PAUSE; count to 5.*) Think about the first time the two of you hung out as friends. What did you do? (*PAUSE; count to 5.*)

What thoughts went through your mind when you first saw ________ or first realized you were or wanted to be friends with him/her. (*PAUSE; count to 3.*) Think about the things the two of you have done together. Think about how you feel when you and ________ do something together. (*PAUSE; count to 3.*)

Think about the times the two of you have laughed together. Think about how you feel when you are with him/her. (*PAUSE; count to 3.*) What things do you like most about ________? (*PAUSE; count to 5.*) The key thing is that all you are thinking about it ________ and all of your feelings for him/her are being felt by you right now. (*PAUSE; count to 5.)*

Now stay focused on all of these thoughts. Take another deep breath, inhale (*PAUSE; count to 2*) and exhale (*PAUSE; count to 3*). Good, you can open your eyes now.

Partner.
Okay, what I want you to do is try to relax and think about your relationship with your partner, ________. I hope that you'll be able to shut out all other thoughts and really focus on your thoughts, feelings, and relationship with ________ and nothing else. To help you do this, I'm going to take you through a brief relaxation exercise. It might seem a little awkward at first, but if you concentrate, you'll be able to stay focused on ________. As part of the exercise, I'm going to ask you to imagine a range of things about your relationship with ________. Sometimes I'll ask you to picture things by prompting you with questions. You DO NOT need to respond; just do your best to create a vivid image of your partner and the two of you by using the prompts. Does that make sense?

I want you to start by closing your eyes and clearing your mind. Try not to think about anything else but the sound of my voice and feeling your body relax. You should slowly notice any tensions in your body and just let each of them go. (*PAUSE; count to 3.*) Good, now take a deep breath, inhale (*PAUSE; count to 2*) and exhale (*PAUSE; count to 3*). Feel yourself relax from the top of your head, down your body, all the way to your toes. All of your tension should be draining away. Inhale (*PAUSE; count to 2*) and exhale (*PAUSE; count to 3*). You should now be able to feel the relaxation of your entire body. Inhale (*PAUSE; count to 2*) and exhale again, letting all the air out of your body (*PAUSE; count to 3*). Good, now your mind is cleared and your body is relaxed (*PAUSE; count to 3*). Now I want you to imagine ________ emerging from the clear space in your mind. (*PAUSE; count to 3.*)

Picture ________'s face and try to visualize all the details about him/her. (*PAUSE; count to 3.*) Think about the first time you saw or met ________ and how he/she made you feel. Picture where you were and what each of you were wearing, and really try to capture and understand the feelings you were having during this time. (*PAUSE; count to 5.*)

What thoughts went through your mind when you first saw ________? (*PAUSE; count to 5.*) Think about the first time the two of you did something as a couple. What did you do? (*PAUSE; count to 5.*)

Think about the first time you realized you were in love with ________. Go ahead and take a moment to recreate this memory as vividly and fully as you can. (*PAUSE; count to 3.*)

Think about the times the two of you have laughed together and how you feel when he/she is close to you. (*PAUSE; count to 3.*) What things do you like most about ________? (*PAUSE; count to 5.*) The key thing is that all you are thinking about it ________ and all of your feelings for him/her are being felt by you right now. (*PAUSE; count to 5.)*

Now stay focused on all of these thoughts. Take another deep breath, inhale (*PAUSE; count to 2*) and exhale (*PAUSE; count to 3*). Good, you can open your eyes now.

Appendix B

Positive Affect Measure (Watson et al., 1988)

Instructions.
Following are a number of words that describe different feelings and emotions. Read each item and then indicate the extent to which you feel this way RIGHT NOW.

1	2	3	4	5
Very slightly or not at all		*Moderately*		*Extremely*

I feel:

1. Interested
2. Distressed
3. Excited
4. Upset
5. Strong
6. Guilty
7. Scared
8. Hostile
9. Enthusiastic
10. Proud
11. Irritable
12. Alert
13. Ashamed
14. Inspired
15. Nervous
16. Determined
17. Attentive
18. Jittery
19. Active
20. Afraid

Appendix C

Ego Depletion Manipulation (Baumeister et al., 1998)

Instructions (control).
Please cross out every letter "e" in the following text.

Instructions (depletion).
Please cross out every letter "e" in the following text, unless it is directly next to or one letter away from another vowel. For example, you would not cross out the "e" in the word "reading" or "towel."

Glomerulus

From Wikipedia, the free encyclopedia.
This article is about the structure in the kidney. For other uses of the term, see Glomerulus (disambiguation).

A **glomerulus** is a capillary tuft that performs the first step in filtering blood to form urine.

It is surrounded by Bowman's capsule in nephrons of the vertebrate kidney. It receives its blood supply from an afferent arteriole of the renal circulation. Unlike most other capillary beds, the glomerulus drains into an efferent arteriole rather than a venule. The resistance of the arterioles results in high pressure in the glomerulus, aiding in the process of ultrafiltration, where fluids and soluble materials in the blood are forced out of the capillaries and into Bowman's capsule.

A glomerulus and its surrounding Bowman's capsule constitute a renal corpuscle, the basic filtration unit of the kidney. The rate at which blood is filtered through all of the glomeruli, and thus the measure of the overall renal function, is the glomerular filtration rate (GFR).

Afferent circulation

The afferent arteriole that supplies the glomerulus is a branch off of an interlobular artery in the cortex.

Layers

If a substance can pass through the endothelial cells, glomerular basement membrane, and podocytes, then it is known as glomerular filtrate, and it enters lumen of proximal tubule. Otherwise, it returns through the efferent circulation, discussed below.

Endothelial cells

The endothelial cells of the glomerulus contain numerous pores (fenestrae) that, unlike those of other fenestrated capillaries, are not spanned by diaphragms. The cells have fenestrations that are 70 to 90 nm in diameter. Hence, most proteins cannot pass through except smaller ones like albumin.

Glomerular basement membrane

The glomerular endothelium sits on a very thick (250-350 nm) glomerular basement membrane. Not only is it uncharacteristically thick compared to most other basement membranes (40-60 nm), but it is also rich in negatively-charged glycosaminoglycans such as heparin sulfate. The negatively-charged basement membrane repels negatively-charged proteins from the blood, helping to prevent their passage into Bowman's space.

Podocytes

Podocytes line the other side of the glomerular basement membrane and form part of the lining of Bowman's space. Podocytes form a tight interdigitating network of foot processes (pedicels) that control the filtration of proteins from the capillary lumen into Bowman's space.

The space between adjacent podocyte foot processes is spanned by a slit diaphragm formed by several proteins including podocin and nephrin. In addition, foot processes have a negatively-charged coat (glycocalyx) that limits the filtration of negatively-charged molecules, such as serum albumin.

The podocytes are sometimes considered the visceral layer of Bowman's capsule, rather than part of the glomerulus.

Intraglomerular mesangial cells

These cells are found in the interstitium between endothelial cells of the glomerulus. They are not part of the filtration barrier but are specialized pericytes that participate indirectly in filtration by contracting and reducing the glomerular surface area, and therefore filtration rate, in response mainly to stretch.

Selectivity

See also: Table of permselectivity for different substances.

The structures of the layers determine their permeability-selectivity permselectivity. The factors that influence permselectivity are the negative charge of the basement membrane and the podocytic epithelium, and the effective pore size of the glomerular wall (8 nm). As a result, large and/or negatively charged molecules will pass through far less frequently than small and/or positively charged ones. For instance, small ions such as sodium and potassium pass freely, while larger proteins such as hemoglobin and albumin have practically no permeability at all.

Efferent circulation

Blood is carried out of the glomerulus by an efferent arteriole instead of a venule, as is observed in most other capillary systems. This provides tighter control over the bloodflow through the glomerulus, since arterioles can be dilated and constricted more readily than venules, owing to arterioles' larger smooth muscle layer (tunica media).

Efferent arterioles of juxtamedullary nephrons (i.e., the 15% of nephrons closest to the medulla) send straight capillary branches that deliver isotonic blood to the renal medulla. Along with the loop of Henle, these vasa recta play a crucial role in the establishment of the nephron's countercurrent exchange system.

The efferent arteriole, into which the glomerulus delivers blood, empties into an interlobular vein.

Juxtaglomerular cells

The walls of the afferent arteriole contain specialized smooth muscle cells that synthesize rennin. These juxtaglomerular cells play a major role in the renin-angiotensin system, which helps regulate blood volume and pressure.

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Appendix D

Anagram Task (Gilhooly & Johnson, 1978)

Instructions.
Now we would like you to complete a word scramble task. You will be asked to rearrange letters to create a five-letter word.

An example is provided below:

PLEPA → APPLE

The task begins on the following page. If you do not know the solution to a scramble you may skip the item and return to it later.

Please work on the task until you have completed all of the word scrambles, or until you have decided to stop working. When you are finished, notify the experimenter.

1. LAKPN → PLANK
2. ECRVO → COVER
3. SRIVU → VIRUS
4. TRHIM → MIRTH
5. AUGRD → GUARD
6. ORHCD → CHORD
7. OUSTC → SCOUT
8. CRIAV → VICAR
9. BNHUC → BUNCH
10. HLSAF → FLASH
11. KTENO → TOKEN
12. FIYAR → FAIRY
13. PHTED → DEPTH
14. EMCYR → MERCY
15. ITRUF → FRUIT
16. HTIWD → WIDTH
17. NRICA → CAIRN
18. CMRBU → CRUMB
19. GITHL → LIGHT
20. YAORV → OVARY
21. TERDN → TREND
22. LCKUP → PLUCK
23. GBTIO → BIGOT
24. TELSY → STYLE
25. FTLRI → FLIRT
26. BOTIR → ORBIT
27. ADEBL → BLADE
28. HMIEC → CHIME
29. IPTLU → TULIP
30. RETIV → RIVET
31. HAEYN → HYENA
32. KASNC → SNACK
33. CHITP → PITCH
34. ACNFY → FANCY
35. ONGYA → AGONY
36. LTIGN → GLINT
37. OFREC → FORCE
38. JEGUD → JUDGE
39. ONARP → APRON
40. FTEIH → THIEF
41. IMENC → MINCE
42. OWAMN → WOMAN
43. NRTOF → FRONT
44. CIAHR → CHAIR
45. IOGLC → LOGIC
46. YQERU → QUERY
47. NIRDK → DRINK
48. PLIBM → BLIMP
49. LKCAO → CLOAK
50. NOEHY → HONEY
51. AVTUL → VAULT
52. HTMNO → MONTH
53. GBRUY → RUGBY
54. HNODU → HOUND
55. EUNDC → DUNCE
56. NEIRB → BRINE
57. OAJMR → MAJOR
58. GIFTH → FIGHT
59. WSHLA → SHAWL
60. HECPR → PERCH
61. CONLW → CLOWN
62. HSLAC → CLASH
63. IUNTY → UNITY
64. IJNOT → JOINT
65. CNHUL → LUNCH
66. KRTCU → TRUCK
67. TCUON → COUNT
68. OCPHR → PORCH
69. ZLTWA → WALTZ
70. RCNAH → RANCH
71. CNIHF → FINCH
72. FNKIE → KNIFE
73. HRCUS → CRUSH
74. HATMC → MATCH
75. HLOVE → HOVEL
76. BNCUH → BUNCH
77. GEVOL → GLOVE
78. UTDBO → DOUBT
79. MACRP → CRAMP
80. ORDCW → CROWD

Appendix E

Ethics Approval

Original.

Office of Research Ethics
The University of Western Ontario
Room 4180 Support Services Building, London, ON, Canada N6A 5C1
Telephone: (519) 661-3036 Fax: (519) 850-2466 Email: ethics@uwo.ca
Website: www.uwo.ca/research/ethics

Western

Use of Human Subjects - Ethics Approval Notice

Principal Investigator: Dr. L. Campbell
Review Number: 17269E **Review Level:** Expedited
Review Date: July 21, 2010 **Approved Local # of Participants:** 180
Protocol Title: Physiology of Romantic Relationships
Department and Institution: Psychology, University of Western Ontario
Sponsor: SSHRC-SOCIAL SCIENCE HUMANITIES RESEARCH COUNCIL
Ethics Approval Date: August 24, 2010 **Expiry Date:** April 30, 2011
Documents Reviewed and Approved: UWO Protocol, Letter of Information and Consent (Paid), Letter of Information and Consent (Credit), Debriefing Letter, Ad, Flyer.
Documents Received for Information:

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced study on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the HSREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of monitor, telephone number). Expedited review of minor change(s) in ongoing studies will be considered. Subjects must receive a copy of the signed information/consent documentation.

Investigators must promptly also report to the HSREB:

a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to this office for approval.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

[redacted]

Chair of HSREB: Dr. Joseph Gilbert
FDA Ref. #: IRB 00000940

Ethics Officer to Contact for Further Information			
☐ Janice Sutherland (jsutherl@uwo.ca)	☐ Elizabeth Wambolt (ewambolt@uwo.ca)	☑ Grace Kelly (grace.kelly@uwo.ca)	☐ Denise Grafton (dgrafton@uwo.ca)

This is an official document. Please retain the original in your files.

cc: ORE File

Revision.

Office of Research Ethics

The University of Western Ontario
Room 4180 Support Services Building, London, ON, Canada N6A 5C1
Telephone: (519) 661-3036 Fax: (519) 850-2466 Email: ethics@uwo.ca
Website: www.uwo.ca/research/ethics

Western

Use of Human Subjects - Ethics Approval Notice

Principal Investigator: Dr. L. Campbell
Review Level: Expedited
Review Number: 17269E
Revision Number: 1
Review Date: November 08, 2010
Approved Local # of Participants: 180
Protocol Title: Physiology of Romantic Relationships
Department and Institution: Psychology, University of Western Ontario
Sponsor: SSHRC-SOCIAL SCIENCE HUMANITIES RESEARCH COUNCIL
Ethics Approval Date: November 08, 2010
Expiry Date: April 30, 2011
Documents Reviewed and Approved: Revised Letter of Information and Consent (Credit), Letter of Information and Consent (Paid) and Compensation.
Documents Received for Information:

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the HSREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of monitor, telephone number). Expedited review of minor change(s) in ongoing studies will be considered. Subjects must receive a copy of the signed information/consent documentation.

Investigators must promptly also report to the HSREB:

a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to this office for approval.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

[redacted]

Chair of HSREB: Dr. Joseph Gilbert
FDA Ref. #: IRB 00000940

Ethics Officer to Contact for Further Information			
☐ Janice Sutherland (jsutherl@uwo.ca)	☐ Elizabeth Wambolt (ewambolt@uwo.ca)	☑ Grace Kelly (grace.kelly@uwo.ca)	

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