Positivity Resonance in Long-Term Married Couples:
Multimodal Characteristics and Consequences for Health and Longevity

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Abstract

The Positivity Resonance Theory of co-experienced positive affect describes moments of interpersonal connection characterized by shared positive affect, caring nonverbal synchrony, and biological synchrony. The construct validity of positivity resonance and its longitudinal associations with health have not been tested. The current longitudinal study examined whether positivity resonance in conflict interactions between 154 married couples predicts health trajectories over 13 years and longevity over 30 years. We used couples' continuous ratings of affect during the interactions to capture co-experienced positive affect and continuous physiological responses to capture biological synchrony between spouses. Video recordings were behaviorally coded for co-expressed positive affect, synchronous nonverbal affiliation cues (SNAC), and behavioral indicators of positivity resonance (BIPR). To evaluate construct validity, we conducted confirmatory factor analysis to test a latent factor of positivity resonance encompassing co-experienced positive affect, co-expressed positive affect, physiological linkage of inter-beat heart intervals, SNAC, and BIPR. The model showed excellent fit. To evaluate associations with health and longevity, we used dyadic latent growth curve modeling and Cox proportional hazards modeling, respectively, and found that greater latent positivity resonance predicted less steep declines in health and increased longevity. Associations were robust when accounting for initial health symptoms, sociodemographic characteristics, health-related behaviors, and individually experienced positive affect. We repeated health and longevity analyses, replacing latent positivity resonance with BIPR, and found consistent results. Findings validate positivity resonance as a multimodal construct, support the utility of the BIPR measure, and provide initial evidence for the characterization of positivity resonance as a positive health behavior.

Keywords: broaden-and-build theory, marriage, positive psychology, affective science, dyadic interaction, health psychology

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Although positive emotions often occur in connection with others – as spouses glance at each other lovingly, friends laugh together about an inside joke, or colleagues put their heads together to solve an intriguing research puzzle – the overwhelming majority of studies to date have examined positive emotions in individuals, using single-subject paradigms. Individuals who experience positive emotions reap many benefits (Fredrickson, 1998, 2001; Harker & Keltner, 2001; Isen, 2000; King et al., 2006; Tugade & Fredrickson, 2004). Prospective, longitudinal, and experimental intervention studies document that positive emotions contribute to well-being (Catalino & Fredrickson, 2011; Fredrickson et al., 2008; Lyubomirsky et al., 2005), health (Kok et al., 2013; Kok & Fredrickson, 2010; Pressman & Cohen, 2005; Richman et al., 2005), and even longevity (Chida & Steptoe, 2008; Diener & Chan, 2011). Affective scientists have only just begun to examine the unique moments of interpersonal connection that arise when one person's positive emotional state simultaneously evokes – and is evoked by – another person's positive emotional state. Grounded in *Positivity Resonance Theory* (Fredrickson, 2013, 2016), the present longitudinal study utilizes a rich dataset on long-term married couples. Our aim is to illuminate the characteristics and consequences of positivity resonance.

Positivity Resonance Theory of Co-Experienced Positive Affect

Drawing from both relationship and developmental science, Fredrickson (2016) proposed Positivity Resonance Theory as a generative way to study the emotion of love within affective science. In this framework, constructs commonly related to "love" (e.g., desire, intimacy, trust, commitments) are understood as products of the accumulation of momentary experiences of love, the emotion, defined as positivity resonance. Expanding on the broaden-and-build theory of positive emotions (Fredrickson, 1998, 2001), moments of positivity resonance are taken to recur between and among individuals and accumulate over time, functioning to build and fortify enduring social bonds (love, the relationship) that later become steady resources for individuals through good times and bad times ("in sickness and in health"). In other words, supportive social bonds—together with their benefits for individuals' health and well-being—emerge from a track record of co-experienced positive affect (c.f., Gable et al., 2012).

Theoretical Contributions

Although emotions often occur in social contexts (e.g., Levenson, 2013; Smith et al., 2004), most studies and theories in affective science focus on the emotions of one person. Even in dyadic research, intraindividual affect often remains the unit of analysis (e.g., the extent to which an individual's affect influences their partner's affect; Carstensen et al., 1995). Indeed, few studies have focused on dyadic, linked emotional processes that transcend the individual (e.g., Levenson & Gottman, 1983; Timmons et al., 2015). Recently, theories of group-level affect have emerged (Butler, 2017; Goldenberg et al., 2020), though they are rarely specific to group-level *positive* affect. Positivity resonance addresses this theoretical gap in affective science by highlighting the distinctive characteristics of co-experienced positive affect as well as its wide-ranging contributions to health and well-being, including relationship health, public health, and—our focus here—physical health and longevity (Brown & Fredrickson, 2021). Positivity resonance itself may serve as a positive health behavior; yet no prior study has examined the effects of positivity resonance on individual health and longevity.

Positivity Resonance Theory was inspired, in part, by prior work in relationship science on perceived partner responsiveness (Reis, 2014), capitalization (i.e., sharing good news; Gable & Reis, 2010) and expressed appreciation (Algoe et al., 2013). Positivity Resonance Theory bridges affective science theory with relationship science theory by targeting holistic and observable patterns of behavior emergent at the group level to offer a more general, cross-cutting construct rooted in affective science. Complementing other seminal theories of relationship science, Positivity Resonance Theory suggests an affective mechanism through which strong attachments (Bowlby, 1969) and positive interdependence among individuals (Thibaut & Kelley, 1959) may occur. Positivity Resonance Theory calls for greater temporal precision to advance scientific understanding of how momentary co-experiences of positive affect may ultimately comprise the building blocks for broader relational constructs (e.g., trust, commitment, relationship satisfaction).

Characteristics

Positivity resonance (Fredrickson, 2013, 2016) refers to moments of interpersonal connection that arise when two or more individuals jointly experience positive emotions that are elevated by the presence of key behavioral and physiological features. Consistent with how an individual's experience of an emotion is coordinated across multiple response systems (i.e., experience, behavior, physiology; Levenson, 2014; Mauss et al., 2005; Wu et al., 2021), moments of *positivity resonance* occur when two or more individuals engage in social interaction characterized by three intertwined, collective responses: (a) shared positive affect (experiential), (b) caring nonverbal synchrony (behavioral), and (c) biological synchrony (physiological).[1] Together, these three key features comprise the holistic experience of positivity resonance.

[1] Note that our current articulation of the three intertwined, defining features of positivity resonance has shifted slightly from its initial presentation (Fredrickson, 2013, 2016). Previously, the trio of collective responses was articulated as "(1) shared positive emotion, (2) mutual care, and (3) biobehavioral synchrony" (Fredrickson, 2016, p. 852). Our new phrasing decouples behavioral from biological synchrony to align better with the operationalized divisions among emotion response systems into experiential (i.e., shared positive-valence affect), behavioral (i.e., caring and synchronized nonverbal behaviors) and biological (i.e., physiological linkage) indicators, as has been done in recent articles (Brown & Fredrickson, 2021; Prinzing et al., 2020; West et al., 2021).

Shared positive affect refers to a pleasant subjective state that is jointly experienced across multiple individuals. Although there are ways that positive affect can be potentially maladaptive (e.g., too much, wrong context; Gruber et al., 2011), the biological, psychological, and social benefits of positive affect are well-documented (e.g., Fredrickson et al., 2008; Kok et al., 2013; Pressman & Cohen, 2005; Sin & Lyubomirsky, 2009). Positivity Resonance Theory posits that these benefits are amplified when positive affect is shared between and among individuals compared to when it is experienced individually. For example, in a laboratory study in which romantic couples discussed how they first met, researchers coded the amount of time spent laughing (either alone or simultaneously with their partner) from video recordings of the conversations, and found that the proportion of time coded as shared laugher (independent of time spent laughing alone) was associated with greater relationship quality, closeness, and social support (Kurtz & Algoe, 2015). In large part, these additional benefits may emerge because positive affect grows more intense and lasts longer when socially shared (e.g., Gable et al., 2004; Kraut & Johnston, 1979). However, Positivity Resonance Theory suggests that even low intensity shared positive affect yields more powerful benefits than does similarly intense positive affect that is experienced individually (Fredrickson, 2016).

Caring nonverbal synchrony encompasses coordinated movements and gestures that momentarily convey investment in the well-being of the other, a purported essential characteristic of love (Hegi & Bergner, 2010). Momentary experiences of love, the emotion, have been linked to four nonverbal affiliation cues: affirmative head nods, Duchenne smiles, non-hostile hand gestures toward the other, and leaning toward the other, which signal approach motivation, commitment, and trust (Gonzaga et al., 2001). Affiliation cues communicate care and responsiveness to one’s partner (Reis et al., 2004), which predict better relationship outcomes (e.g., relationship well-being and longevity; Gable et al., 2006) and physical health (e.g., lower mortality risk; Selcuk & Ong, 2013). Affiliation cues may also become mirrored and synchronized into a “dance” of mutual attentiveness, positivity, and behavioral coordination (Bernieri et al., 1988; Tickle-Degnen & Rosenthal, 1990; Vacharkulksemsuk & Fredrickson, 2012). A hallmark of positive interpersonal exchanges, behavioral synchrony can emerge as early as infancy (i.e., between infants and their caregivers; Meltzoff & Moore, 1989) and can occur cross-modally (i.e., beyond mimicry), such as when the rhythm of an infant’s movements syncs up with the rhythm of a mother’s vocalizations (Stern et al., 1985). Laboratory studies of adults show that synchronized body movements facilitate perceptions of embodied rapport (Vacharkulksemsuk & Fredrickson, 2012), compassion (Valdesolo & Desteno, 2011), emotional support satisfaction (Jones & Wirtz, 2007), and affiliation (Hove & Risen, 2009). Therefore, we believe synchronized body movements that further indicate care, love, and affiliation (i.e., caring nonverbal synchrony) represent a key component of high-quality moments of connection.

Biological synchrony occurs when biological response systems (e.g., physiological, biochemical, neural) of two or more people change in coordinated ways. Consistent with Positivity Resonance Theory, empirical evidence shows that biological synchrony emerges when two or more people share a positive emotional state. For example, parent-infant pairs show synchrony in oxytocin levels during mutual positive engagement (Feldman et al., 2010). Neuroimaging studies also reveal widespread neural synchrony within dyads and groups sharing a positive emotional experience (Hasson et al., 2004; Stephens et al., 2010). Synchrony in autonomic physiology (also called “physiological linkage”) has been related to favorable outcomes such as higher relationship quality (Helm et al., 2014), greater patient perceptions of therapist empathy (Marci et al., 2007), and social bonding (for a review, see Feldman, 2015).

However, evidence for the association between physiological linkage and relationship outcomes has been mixed (Timmons et al., 2015), which may reflect differing methods for measuring linkage. For instance, early research on this topic found that greater *overall* physiological linkage (a grand average measured over long time periods, e.g., across an entire 15-minute conversation) was associated with adverse outcomes, such as lower marital satisfaction (Levenson & Gottman, 1983). For the present study, because we view emotions (e.g., love) as short-lived phenomena, we consider *momentary* physiological linkage during seconds characterized by shared positive affect to be a more appropriate method for capturing biological synchrony, rather than overall, or *grand average*, linkage (Chen et al., 2020; described more fully below).

Associations Among Defining Features

Each of the three defining features of positivity resonance is theoretically aligned with a particular emotion response system (i.e., subjective experience, behavior, physiology). According to a number of emotion theorists, emotions involve coordinated changes across these response systems, a process often referred to as *emotion coherence* (Ekman, 1992; Levenson, 1994). Building on this idea of within-person emotion coherence, Positivity Resonance Theory suggests that high-quality moments of connection involve further coordination, occurring *across* individuals, as reflected by the co-occurrence of its three key features. Although research has evaluated emotional responding across individuals in the same response system (e.g., emotional convergence of subjective experience, synchrony in physiological responses; Anderson et al., 2003; Levenson & Gottman, 1983), less is known about the multimodal, interpersonal emotion coherence that is theorized to occur during moments of positivity resonance.

Consequences

Preliminary evidence suggests that positivity resonance may promote health and well-being. Initial research on the consequences of positivity resonance found that participants who, over a 9-week period of nightly self-reports, showed increases in feeling "close" and "in tune" with others (a possible proxy for shared positive affect and caring nonverbal synchrony) had increases in cardiac vagal tone (Kok & Fredrickson, 2010), which is correlated with physical health (Bibevski & Dunlap, 2011; Thayer & Sternberg, 2006). The first published empirical research on positivity resonance validated a new self-report measure of perceived positivity resonance and showed that it is associated, within individuals, with flourishing mental health, fewer depressive symptoms, loneliness, and (albeit less consistently) illness symptoms, even when controlling for daily pleasant emotions or amount of social interaction more generally (Major et al., 2018). More recent research that used this same measure of perceived positivity resonance during the early months of the COVID-19 pandemic found it to account for the link between trait resilience and mental health (Prinzing et al., 2020) and also to predict behaviors known to promote public health (i.e., handwashing, mask wearing, and social distancing), as mediated by prosocial tendencies (West et al., 2021). Here, we aim to advance this prior work by measuring positivity resonance through a suite of objective, dyad-level methods and in a social context (i.e., long-term marriage) to further illuminate its longitudinal consequences for health and longevity.

Development of Objective and Dyad-Level Measures of Positivity Resonance

Longitudinal Study of Long-Term Married Couples

Through a series of studies using data from the same dataset analyzed here, we developed and validated new, dyad-level measures of positivity resonance using multiple methods. This dataset draws from an unparalleled longitudinal study of middle-aged and older couples in long-term marriages (Levenson et al., 1993; Levenson et al., 1994). In the first laboratory session of the study, couples engaged in three 15-min conversational interactions: (a) a discussion of the events of the day, (b) a discussion of an area of continuing disagreement in their marriage, and (c) a discussion of a mutually agreed upon pleasant topic. For the present study, we measured positivity resonance during the discussion of a disagreement (i.e., conflict conversation), a context that is familiar to most couples and one that is rich with not only negative but also positive emotion (Haase et al., 2013; McGonagle et al., 1992), to maximize ecological validity.

Defining Features

In our study of *shared positive affect*, we utilized each spouse's moment-by-moment ratings of their individual affective experience during the interactions, which they provided by continuously moving a rating dial while watching the video-recordings of their interactions. We found that co-experienced positive affect (the number of seconds in which both spouses reported feeling positive), more than individually experienced positive affect (the number of seconds in which one partner reported feeling positive and the other did not) was associated with greater marital satisfaction (Brown et al., 2021). In another study, we measured *caring nonverbal synchrony* during the conflict interaction by applying a dyad-level modification to a behavioral coding system developed by Gonzaga and colleagues (2001), coding the same nonverbal affiliation cues (e.g., head nods, smiles) that have been associated with love (versus desire), yet with exclusive focus on those occurring synchronously (i.e., both partners displayed an affiliation cue near simultaneously). Preliminary analyses suggest that synchronized nonverbal affiliation cues are positively associated with wives' perceptions of husbands' lovingness (Lai et al., in prep).

In our study of *biological synchrony*, we measured physiological linkage over short time periods (i.e., 15-second rolling time windows) in the conflict interaction during four emotion categories defined by behavioral coding: co-expressed positive emotion, co-expressed negative emotion, co-expressed neutral emotion (i.e., both showed no emotion), and individually expressed emotion (Chen et al., 2020). Results revealed that co-expressed positive emotion, relative to all other emotion categories, is associated with greater in-phase physiological linkage (responses changing in the same direction) and lower anti-phase physiological linkage (responses changing in opposite directions). Greater in-phase physiological linkage during co-expressed positive emotion was also positively associated with the overall affective quality of the interaction and marital satisfaction (Chen et al., 2020). Further, the *momentary* physiological linkage approach outperformed the *grand average* approach (i.e., measuring linkage across the entire conversation) in its associations with related constructs like affective and marital quality, and thus appears to be a more useful measure for evaluating positivity resonance.

Holistic Measure

Positivity Resonance Theory suggests that its three defining features may combine synergistically and be particularly powerful when they co-occur, rather than when they occur separately. Motivated by this hypothesis, we created a novel, group-level measure of behavioral indicators of positivity resonance (BIPR) that integrates multiple features of positivity resonance (e.g., shared positive affect, mutual care and concern, and behavioral synchrony). This behavioral coding system combines actions, words, and voice intonation that convey mutual warmth, concern, affection and/or a shared tempo into one holistic measurement of positivity resonance. In the initial study of BIPR, we found that it is a more potent predictor of marital satisfaction than a behavioral measure of co-expressed positive affect alone (i.e., without consideration of mutual care or behavioral synchrony; Otero et al., 2019).

In sum, we have begun to examine positivity resonance, its characteristics, and correlates using the present longitudinal dataset of long-term married couples. Importantly, no prior study has investigated the multimodal construct validity of positivity resonance nor its longitudinal associations with health and longevity. Moreover, important unanswered questions remain regarding for whom (e.g., women versus men) positivity resonance may be the most beneficial and how it is best assessed (e.g., using one or multiple measures).

Additional Questions

Gender Differences

Positivity resonance is a group-level phenomenon (Fredrickson, 2016), and is thought to be beneficial to all those who experience it. However, gender-specific effects are common in marital research on heterosexual couples (Baucom et al., 1990; Kiecolt-Glaser & Newton, 2001). Evidence is mixed regarding whether the effects of relationships on health are stronger for women versus men, including studies using the same longitudinal dataset as used here (Bloch et al., 2014; Haase et al., 2016; Levenson et al., 1993), as well from other studies. For example, a 15-year study using medical records found relationship characteristics (e.g., companionship, equality in decision-making) to be associated with a lower risk of death in married women, but not men (Hibbard & Pope, 1993). At the same time, evidence supports the opposite conclusion, that men's health may be more closely tied to aspects of the marriage. Laboratory studies of marital conflict have linked hostility with heightened cardiovascular reactivity (Smith & Gallo, 1999); anger with increases in blood pressure (Miller et al., 1999); and stonewalling with lower physical health (Gottman, 1991) – for men, in particular.

A large body of evidence also points to gender differences in emotion and social relationships. Women tend to be more emotionally expressive than men (for a review, see Brody & Hall, 2000), as measured by observational coding (e.g., Kring & Gordon, 1998) and facial electromyography (e.g., Bradley et al., 2001). Compared to men, women smile more when engaging with others (LaFrance et al., 2003) and express more voiced laughter (Bachorowski et al., 2001), which elicits more positive affect in listeners than unvoiced laughter (Bachorowski & Owren, 2001). Additionally, women have larger social networks compared to men and are more likely to maintain active friendships throughout their lives (Candy et al., 1981; Field & Minkler, 1988). These patterns suggest that women may have more opportunities for social interactions than men—and may be more likely than men to express positive affect, experience positive affect themselves, and to elicit positive affect in their interaction partners. Conceivably, women who tend to cultivate positivity resonance in their marriage may also do so in other social relationships, potentially resulting in higher overall “doses” of positivity resonance for wives, compared to their husbands.

Given somewhat inconsistent evidence for gender differences in the scientific literatures on marriage, emotion, and relationships, we did not have a specific hypothesis regarding whether couples’ positivity resonance may be more important for wives’ or husbands’ health and longevity. Positivity Resonance Theory also makes no predictions about gender differences. Thus, we explored this question in the present study.

Measurement Parsimony

Positivity Resonance Theory proposes that the combination of shared positive affect, caring nonverbal synchrony, and biological synchrony promote long-term health outcomes, above and beyond any single feature in isolation. However, given the practical constraints of many research settings, it may not be possible to assess all these features simultaneously. Thus, the holistic behavioral measure of positivity resonance, BIPR, may be a useful tool for researchers with more limited resources. It remains to be determined whether BIPR would perform as well as a comprehensive latent factor that incorporates multiple measures and features of positivity resonance in predicting long-term health and longevity.

Long-Term Marriage as a Context for Studying Positivity Resonance

Marriages are among the most significant relationships in adult life (more than 94% of U.S. Americans over the age of 55 have been married at least once; U.S. Bureau of the Census, 2011). Marriages may be especially significant in later life as social networks shrink and close relationships become increasingly important (Carstensen et al., 1999). A long line of research has evaluated characteristics of marriages that are associated with different health-related outcomes, with particular focus on spouses' emotional functioning (Gottman & Levenson, 1986; Levenson et al., 2013; Smith et al., 2014), which is known to have downstream consequences for well-being (e.g., Carr et al., 2014; Glenn & Weaver, 1981), mental health (e.g., Beach, 2014; Beach et al., 1998), and physical health (e.g., Haase et al., 2016; Kiecolt-Giaser et al., 1993; Robles & Kiecolt-Glaser, 2003). Much of this work was devoted to uncovering negative emotional qualities of marriages and their consequences (e.g., Gottman & Levenson, 1992; Kiecolt-Giaser et al., 1993). More recently, another line of research has emerged documenting the positive emotional qualities of marriage and close relationships (e.g., Algoe et al., 2013; Gable et al., 2004; Laurenceau et al., 2005), and the consequences these positive qualities have, independent of the adverse effects of negative emotions (e.g., Algoe, 2019; Feeney & Collins, 2015; Pietromonaco & Collins, 2017).

Emotions may have especially long-lasting consequences, such as predicting longevity, in the context of long-term marriage, given the duration and importance of this relationship. Indeed, individuals who rate their marriage as happier have significantly lower odds of dying (Whisman et al., 2018). Beyond intrapersonal associations among emotion, marriage, and longevity, there is also evidence that having a happier spouse predicts greater longevity in elderly couples (Stavrova, 2019). Moreover, greater self-reported perceived partner responsiveness (i.e., a key feature of caring nonverbal synchrony) has been linked with lower all-cause mortality in romantic couples (Selcuk & Ong, 2013; Stanton et al., 2019). Additional research is needed to explore whether interpersonal emotional processes at the level of the dyad (e.g., positivity resonance) predict health and longevity in long-term married couples; and further, whether these predictions are independent of individual-level emotions, marital quality, or both.

Importance of Longitudinal Assessment

It is important to utilize a longitudinal design when studying associations between emotions and health. Positivity resonance may well be linked to present-day health and well-being, as is suggested (albeit inconsistently) by Major et al. (2018). Yet, we expect its effects may be amplified throughout the course of relationships, as moments of positivity resonance recur and accumulate over time (Fredrickson, 1998, 2001). The effects of relationships on health may also become stronger over time, as individuals age and their social networks shrink (Rook & Charles, 2017). Additionally, health is known to decline with age (Pinquart, 2001), and positivity resonance may promote health longitudinally by protecting against these normative declines in health. Therefore, health consequences of positivity resonance in marriages may be more evident longitudinally than cross-sectionally. For examining these kinds of questions, longitudinal designs clearly have advantages over more common cross-sectional designs.

The Present Study

Using the present rich, longitudinal dataset (Levenson et al., 1993; Levenson et al., 1994), we have recently developed novel, objective, dyad-level measures of positivity resonance (i.e., Brown et al., 2021; Chen et al., 2020; Lai et al., in prep; Otero et al., 2019). The present study had two aims: (1) to examine the covariance among these measures through a measurement model of positivity resonance as a single latent factor (i.e., through confirmatory factor analysis [CFA]); and (2) to use this latent factor to predict longitudinal health trajectories and longevity.

To pursue our first aim, we conducted CFA to test a measurement model of positivity resonance, indicated by our dyad-level measures. Our first hypothesis (Hypothesis 1) was that the CFA would fit satisfactorily, supporting the existence of a broader positivity resonance construct with multimodal manifestations of its defining features, objectively assessed at the dyadic level, in the domains of experience, behavior, and physiology. To pursue the second aim, we conducted two series of analyses examining whether couples' positivity resonance (measured at the first timepoint) predicted (a) longitudinal trajectories of wives' and husbands' health symptoms (measured at three timepoints, separated by approximately 6-7 years) as well as (b) mortality (measured over the ensuing 20 years). We hypothesized that greater positivity resonance would be associated with less steep declines in health (Hypothesis 2) and increased longevity (Hypothesis 3) in both wives and husbands. Analyses for Hypotheses 2 and 3 proceeded in five steps: (1) We conducted preliminary analyses to verify selection of model parameters; (2) We examined associations of our latent factor of positivity resonance with health trajectories (controlling for health at T1) and longevity, respectively; (3) We explored whether gender moderated associations of latent positivity resonance with health and longevity; (4) We examined the robustness of our findings by controlling for (a) sociodemographic factors (e.g., age, education), behaviors known to influence health (e.g., smoking, exercise), and individually experienced positive affect during the conflict discussion at the first timepoint (to investigate the added value of dyad-level, co-experienced positive affect, independent of individually experienced positive affect), and (b) marital satisfaction; and (5) Finally, to examine whether associations with health trajectories and longevity could be obtained with a single behavioral measure of positivity resonance, we repeated longitudinal analyses replacing our latent factor of positivity resonance, as the independent variable, with BIPR.

Method

Participants

We analyzed archival data from a longitudinal study of 156 heterosexual long-term married couples. The current sample (*N* = 154 couples; *n* = 2 couples excluded due to missing data) was comprised of a middle-aged cohort (*n* = 80 couples; *M* age = 44.33 years; *SD* age = 2.92 years) and an older adult cohort (*n* = 74 couples; *M* age = 63.54 years; *SD* age = 3.21 years). The sample was recruited from the San Francisco Bay Area to be representative of the demographic characteristics (socioeconomic status, religion, ethnicity) of couples in these age groups in that area at the time of the study. The resulting sample was primarily white (86%), Protestant or Catholic (62%), relatively well-off socioeconomically, and with children (96% of couples had at least one child). Complete details of the sampling and recruitment procedures have been reported previously (Levenson et al., 1993). Several prior studies have analyzed data from this sample (e.g., Bloch et al., 2014; Brown et al., 2021; Chen et al., 2020; Haase et al., 2016; Otero et al., 2019; see **Previous Publications** and **Supplemental References**, Online Supplemental Materials), mostly focusing on the early waves of assessment. However, no prior studies have examined longitudinal associations between positivity resonance and health or longevity.

Procedure

Data were initially collected at three time points over the course of approximately 13 years (Time 1 (T1): 1989/90, N = 154 couples; Time 2 (T2): 1995/96, n = 131 couples; Time 3 (T3): 2001/02, n = 101 couples). Longevity data were collected during a follow-up phase 30 years later, spanning from June 1, 2020 to April 1, 2021. Attrition in the sample occurred when couples discontinued participation for the following reasons (cumulative frequencies): (a) divorce (T2: n = 5; T3: n = 8); (b) death of a spouse (T2: n = 10; T3: n = 25), or (c) declined/unknown reasons (T2: n = 8; T3: n = 21). We also examined whether health symptoms and positivity resonance were associated with drop-out. Health symptoms at T1 did not predict drop-out over time. Positivity resonance at T1 was associated with drop-out at T3, $t(147.54) = 5.36$, $p < .001$); couples who discontinued the study at T3 had lower positivity resonance ($M = -0.46$, $SD = 0.63$) than those who continued in the study ($M = 0.24$, $SD = 1.01$). We used full information maximum likelihood estimation (FIML; e.g., Jeličić et al., 2009) to account for missing data in the CFA and throughout the longitudinal health trajectory analyses.

At each time point, couples completed questionnaires and participated in a laboratory session that followed well-established procedures for studying marital interactions (Levenson & Gottman, 1983). Couples engaged in three 15-minute conversations: (a) events of the day (T1) or events since the last assessment (T2 and T3); (b) conflict topic – an issue of ongoing disagreement in their marriage; and (c) pleasant topic – something they enjoyed doing together. The present study analyzed data from the conflict conversation only.

Partially hidden cameras were used to videotape each interaction for subsequent behavioral coding (see below). Several days after each laboratory session, each participant returned to the laboratory to watch video-recordings of their conversations, individually, while providing continuous ratings of how they felt during the interactions using a rating dial, consisting of small metal box with a rotating pointer that traversed a 180° path (a well-validated procedure for obtaining continuous self-reported affect; Gottman & Levenson, 1985). Participants continuously moved the rating dial across a 9-point scale anchored by the legends "extremely negative" (1) and "extremely positive" (9), with a line labeled "neutral" in the middle (5). The dial generated a voltage that reflected the dial position; a computer sampled the voltage 100 times per second, and computer software developed by Robert W. Levenson computed the average dial position every second.

Couples' physiological responses were recorded continuously throughout all interactions using a Grass Model 7 12-channel polygraph and the same computer that was used for sampling rating dial voltage (described above). For the present study, we focus on linkage in inter-beat intervals (IBI) of the heart, because this physiological channel showed the highest effect sizes in the original study of physiological linkage (Chen et al., 2020), relative to the other physiological indices, and as such appears to be more sensitive to changes in dyadic emotion. Cardiac IBI was obtained using Beckman miniature electrodes with Redux paste that were placed in a bipolar configuration on opposite sides of the participant's chest. IBI was measured as the interval between successive R-waves of the electrocardiogram was measured in milliseconds.

All procedures were approved by the University of California, Berkeley Committee for the Protection of Human Subjects. This study was not preregistered.

Measures

Positivity resonance (T1)

Couples' positivity resonance was modeled as a latent variable, indicated by five dyad-level measures (each measure is listed as a subheading and described below). Each dyad-level measure was calculated across the entire 15-minute conflict conversation to obtain one value for each couple, such that all measures are temporally comparable and reflect the same time period. Descriptive statistics, sample sizes, and intercorrelations among dyad-level positivity resonance variables are provided in **Table 1**.

Table 1

Descriptive Statistics and Intercorrelations Among Positivity Resonance Latent Factor and its Dyad-Level Indicators

Variables	1	2	3	4	5	Mean	SD	Min	Max	*n*
1. Positivity resonance (factor scores)						0	0.96	-1.09	3.53	154
2. BIPR	0.98***					5.92	5.89	0	32	148
3. SNAC	0.87***	0.79***				12.3	10.37	0	46	147
4. Co-expressed positive affect	0.64***	0.56***	0.52***			26.44	31.01	0	149	150
5. Co-experienced positive affect	0.28**	0.25**	0.16*	0.29***		260.91	229.6	0	900	153
6. In-phase IBI linkage[a]	0.26**	0.26**	0.19*	0.08	-0.01	0.44	0.23	0	0.99	114

Note. BIPR = Behavioral Indicators of Positivity Resonance. SNAC = Synchronized Nonverbal Affiliation Cues. SD = standard deviation. Min = minimum. Max = maximum. IBI = inter-beat interval. [a]during co-expressed positive affect. * $p < .05$. ** $p < .01$. *** $p < .001$.

Behavioral Indicators of Positivity Resonance (BIPR). Couples' behavior was coded using a dyad-level coding system (Otero et al., 2019) that captured holistic, integrated behavioral indications of positivity resonance using the following prompt: *"Did positivity resonate between the two partners? That is, did they show actions, words, or voice intonation that conveyed mutual warmth, mutual concern, mutual affection and/or a shared tempo (i.e., shared smiles and laughter)?"* Three trained coders viewed the videotaped conflict interactions and rated BIPR every 30 seconds on a 3-point intensity scale (0 = not present; 1 = lower intensity or present once; and 2 = higher intensity or present more than once). Coders did not evaluate the presence of negative emotional behaviors in their BIPR ratings; that is, negative emotional behaviors were not weighted against indications of positivity resonance that occurred in the same coding period. To assess interrater reliability, all three coders coded 20% of the study sample. Reliability was high (intraclass correlation coefficient = .80). Codes were summed across all 30-second periods to obtain one BIPR score for the entire conversation.

Synchronized Nonverbal Affiliation Cues (SNAC). Couples' synchronized nonverbal affiliation cues (i.e., caring nonverbal synchrony) were assessed using a recently developed behavioral coding system that captures simultaneous or near-simultaneous nonverbal affiliation cues between partners (Lai et al., in prep). SNAC is based on a coding system that captures four nonverbal displays of love/affiliation at the individual-level (e.g., head nods, smiles, forward leans, and non-hostile hand gestures; Gonzaga et al., 2001). An independent team of trained coders (i.e., different coders than those who coded BIPR) viewed the videotaped conflict interactions, without audio, and rated SNAC every 30 seconds on a 0-2 scale. Again, coders did not take into consideration expressions of negative emotional behaviors (e.g., frowns). Codes were averaged across coders (reliability was high; intraclass correlation coefficient = .86-.90) and summed across all 30-second periods to obtain one SNAC score for the entire conversation.

Co-Expressed Positive Affect. Each spouse's emotional behavior was coded using the Specific Affect Coding System (SPAFF; Coan & Gottman, 2007), which evaluated verbal content, voice tone, context, facial expression, gestures, and body movements. There are five positive speaker codes (interest, affection, humor, validation, joy), nine negative speaker codes (anger, contempt, disgust, belligerence, domineering, defensiveness, fear/tension/worry, sadness, whining), and three listener emotion codes (positive, negative, stonewalling). An independent team of trained coders viewed the videotaped conflict interactions and rated each spouse's emotional behaviors on a second-by-second basis. For both speakers and listeners, a "neutral" code (0 = absent, 1 = present) was assigned for seconds in which neither positive nor negative emotional behavior were coded. Interrater reliability of the SPAFF coding was satisfactory (overall mean kappa = .64). Additional details regarding SPAFF reliability in this sample has been published elsewhere (Carstensen et al., 1995). Co-expressed positive affect was calculated for each couple as the number (sum) of seconds in which both partners were simultaneously coded with a positive SPAFF code (i.e., either as a speaker or listener; regardless of intensity). In other words, this measure is specific to the *cumulative duration* of co-expressed positive affect and does not take intensity into consideration. In addition, moments of individually experienced positive affect (i.e., seconds in which one partner expresses positive affect while the other partner expresses negative or neutral affect) are not counted towards this variable.

Co-Experienced Positive Affect. The average rating dial position for each spouse's ratings of how they felt during the conflict interaction was computed for every second. Following data reduction procedures from the validation study of shared positive affect, couples' co-experienced positive affect was recorded as the number (sum) of seconds in which both partners reported experiencing positive affect (>=5 or "neutral"[2] on the rating dial at the same time; Brown et al., 2021). Again, this measure is specific to the *cumulative duration* of co-experienced positive affect, regardless of intensity, and only includes co-experienced, rather than individually experienced, positive affect.

In-Phase IBI Linkage. IBI data for the conflict interaction were averaged every second and smoothed using a 10-second rolling time window. For each couple, a time series of total IBI linkage was computed by calculating Pearson's correlations between both partners' IBI responses within 15-second rolling time windows (Marci et al., 2007; Marci & Orr, 2006). We then computed a time series of in-phase IBI linkage by entering the correlation coefficient from the total linkage time series if it was positive or entering a 0 if the correlation was 0 or negative. In the present study, we examine momentary in-phase IBI linkage during moments of co-expressed positive affect, given its previous association with marital satisfaction (Chen et al., 2020). We calculated the average degree of in-phase IBI linkage during moments of co-expressed positive affect by taking the average level of in-phase IBI linkage across all seconds where both partners were simultaneously coded with a positive SPAFF code (see above).

Health Symptoms (T1, T2, T3)

Health symptoms were measured using the Cornell Medical Index (CMI; Brodman et al., 1949). The CMI is a well-established self-report measure that contains 195 items assessing a variety of mental and physical health symptoms. The CMI shows high convergence with medical

[2] As in the validation study (Brown et al., 2021), we included the neutral line (5 on the rating dial) in the threshold for determining positive affect because (a) Positivity Resonance Theory posits that even low intensity co-experienced positive affect is beneficial (Fredrickson, 2016) and (b) given the nature of the rating dial, participants necessarily move through the neutral line in order to shift from negative to positive affect, without necessarily feeling neutral.

evaluations of health and predicts morbidity over time (Weaver et al., 1980). Because we wanted to focus on current health, we excluded 13 CMI items that assessed family history of illness and 5 items assessing behaviors known to influence health, such as smoking and drinking (as has been done in previous studies using the CMI; e.g., Aldwin et al., 1989; Aldwin et al., 2001; Haase et al., 2016). To reduce skew, items were recoded (0 = symptom not present; 1 = symptom present [regardless of intensity]) following established procedures (e.g., Duncan et al., 2006; Haase et al., 2016). A total health symptoms score was calculated at each timepoint by taking the sum of all items (excluding family history and health-related behaviors). Lower scores on the CMI indicate better health, with 0 representing no symptoms and 177 representing the highest total possible score. Descriptive statistics for health symptoms and covariates are presented in **Table 2**.

Table 2

Descriptive Statistics for Key Individual-Level Study Variables

	Wives		Husbands	
	Mean (SD)	Range	Mean (SD)	Range
T1 health symptoms	18.82 (14.95)	2 - 129	13.47 (8.53)	0 - 50
T2 health symptoms	19.76 (13.08)	2 - 82	14.23 (9.60)	0 - 56
T3 health symptoms	18.76 (11.58)	2 - 56	14.67 (9.22)	0 - 61
Age	52.91 (10.03)	37 - 70	54.21 (10.17)	39 - 70
Household income (*n* =)				
less than $10,000	1		1	
$10,000 - $19,999	3		3	
$20,000 - $29,999	6		6	
$30,000 - $39,999	16		16	
$40,000 - $49,999	25		25	
$50,000 - $59,999	28		28	
$60,000 - $69,999	23		23	
$70,000 - $79,999	14		14	
$80,000 - $89,999	14		14	
$90,000 - $99,999	6		6	
$100,000 or more	17		17	
Education	23.44 (7.10)	8 - 34	26.46 (7.38)	10 - 35
Health-related behaviors	0.80 (0.90)	0 - 4	0.74 (0.88)	0 - 3
Individual[a] PA	208.83 (208.58)	0 - 900	170.47 (178.69)	0 - 869
Marital satisfaction	111.3 (16.91)	46.5 - 138	111.3 (17.08)	43.5 - 138

Note. Household income is a dyad-level covariate; values are the same across wives and husbands. [a]Individually experienced. PA = positive affect. SD = Standard deviation; T1 = Time 1; T2 = Time 2; T3 = Time 3.

Mortality

Between the beginning of the study in 1989 and the start of the search period for collecting mortality data (June 1, 2020), 135 deaths were confirmed (43.8%). Deceased participants' date of death was obtained from report of relatives (n = 36), the United States Social Security Death Index database (http://ssdi.genealogy.rootsweb.com; n = 54); online obituary listings (n = 36), or through another online search engine (i.e., facebook.com, intelius.com; n = 9), following procedures used successfully in previous studies collecting longitudinal or mortality data (e.g., Bolanos et al., 2012; Engoren et al., 2002; Shelton et al., 2018; van Kimmenade et al., 2010). Survival time was computed as the number of days between the date of their initial laboratory visit and the date of death. We confirmed that 145 participants (45.1%) were still alive after June 1, 2020 through phone/email contact with participants and their relatives (n = 136) and social media (e.g., facebook.com, linkedin.com; n = 9). Data from participants who had not died (i.e., their exact survival time is unknown) were censored, a common data estimation technique used in survival analysis when the event of interest has not yet occurred (Finkelstein, 1986). Censor time for these participants was computed as the number of days between the date of their initial laboratory visit and June 1, 2020 (Leon et al., 1990). For the remaining 28 participants (9.5%) whose status was not confirmed within our search period (06/01/2020 and 04/01/2021), censor time was conservatively computed as the number of days between the date of their initial laboratory visit and their last known date alive (i.e., last laboratory visit or questionnaire completion).[3]

Covariates (T1)

Sociodemographic Characteristics. Sociodemographic characteristics included age (in years), annual household income before taxes (coded: 0 = less than $10,000; 1 = $10,000 - $19,999; 2 = $20,000 - $29,999; 3 = $30,000 - $39,999; 4 = $40,000 - $49,999; 5 = $50,000 -

[3] When we exclude participants whose living status is unknown (n = 28) from mortality analyses, results were consistent.

$59,999; 6 = $60,000 - $69,999; 7 = $70,000 - $79,999; 8 = $80,000 - $89,999; 9 = $90,000 - $99,999; and 10 = $100,000 or more), and education (in years).

Health-Related Behaviors. Health-related behaviors included smoking (≥ 20 cigarettes per day), alcohol consumption (≥ 2 drinks a day), caffeine consumption (≥ 6 cups of coffee or tea per day), and lack of physical exercise from the CMI (recoded as 0 = no, 1 = yes) and summed.

Individually Experienced Positive Affect. Individually experienced positive affect was determined separately, for wives and husbands, as the number (sum) of seconds in which the individual reported experiencing positive affect (>=5 on the rating dial), while their partner did not.

Marital Satisfaction. Marital satisfaction was assessed using two well-validated self-report inventories: (a) the 15-item Marital Adjustment Test (Locke & Wallace, 1959), which assesses agreement between spouses in various life domains (e.g., handling family finances, demonstrations of affection); and (b) the 22-item Marital Relationship Inventory (Burgess et al., 1971), which measures satisfaction with affection and sexuality in the marriage, overall satisfaction with the marriage, and areas of agreement (e.g., “How happy would you rate your marriage?”). Consistent with previous research (e.g., Carstensen et al., 1995) and to reduce Type 1 error, we averaged the measures separately for husbands and wives to capture each spouse’s marital satisfaction.

Analytic Approach

The present study used subjective experiential, behavioral, and physiological data obtained during the conflict conversation at T1 to measure positivity resonance; self-reported questionnaire data obtained at T1, T2, and T3; and mortality data obtained between June 1, 2020 and April 1, 2021 (see above). Preliminary CFA and longitudinal health trajectory analyses were conducted within a structural equation modeling (SEM) framework, employing FIML to handle missing data, through the *lavaan* package in R Studio Version 1.2.1335 (Rosseel, 2012). To evaluate model fit in SEM, we inspected the χ^2 test of model fit as an absolute fit index as well as the comparative fit index (CFI) and standardized root mean squared residual (SRMR) as relative fit indices, following established guidelines (Hu & Bentler, 1999). Nonsignificant χ^2 values (ps > 0.05); CFI values greater than 0.95 and SRMR values less than .08 were used to indicate satisfactory model fit. Mortality analyses were conducted using the *survival* package (v3.2-11; Therneau, 2020). All continuous variables were standardized before analysis.

Preliminary Analyses

First, we examined intercorrelations among dyad-level variables (see **Table 1**) and individual-level variables (see **Table 2**). Next, we conducted analyses to validate the assessment of our key constructs (i.e., positivity resonance, health trajectories).

Positivity resonance. We evaluated the construct validity of positivity resonance, a dyad-level latent variable indicated by an a priori set of observed indicator variables, using CFA. We tested a measurement model of positivity resonance based on the following dyad-level indicator variables: BIPR, SNAC, co-expressed positive affect, co-experienced positive affect, and average in-phase IBI linkage during co-expressed positive affect. To reduce the number of parameters, we factor scored the latent positivity resonance variable to obtain model-implied values (i.e., weighting observed values based on parameter estimates and standardizing) for use in all subsequent analyses (DiStefano et al., 2009).

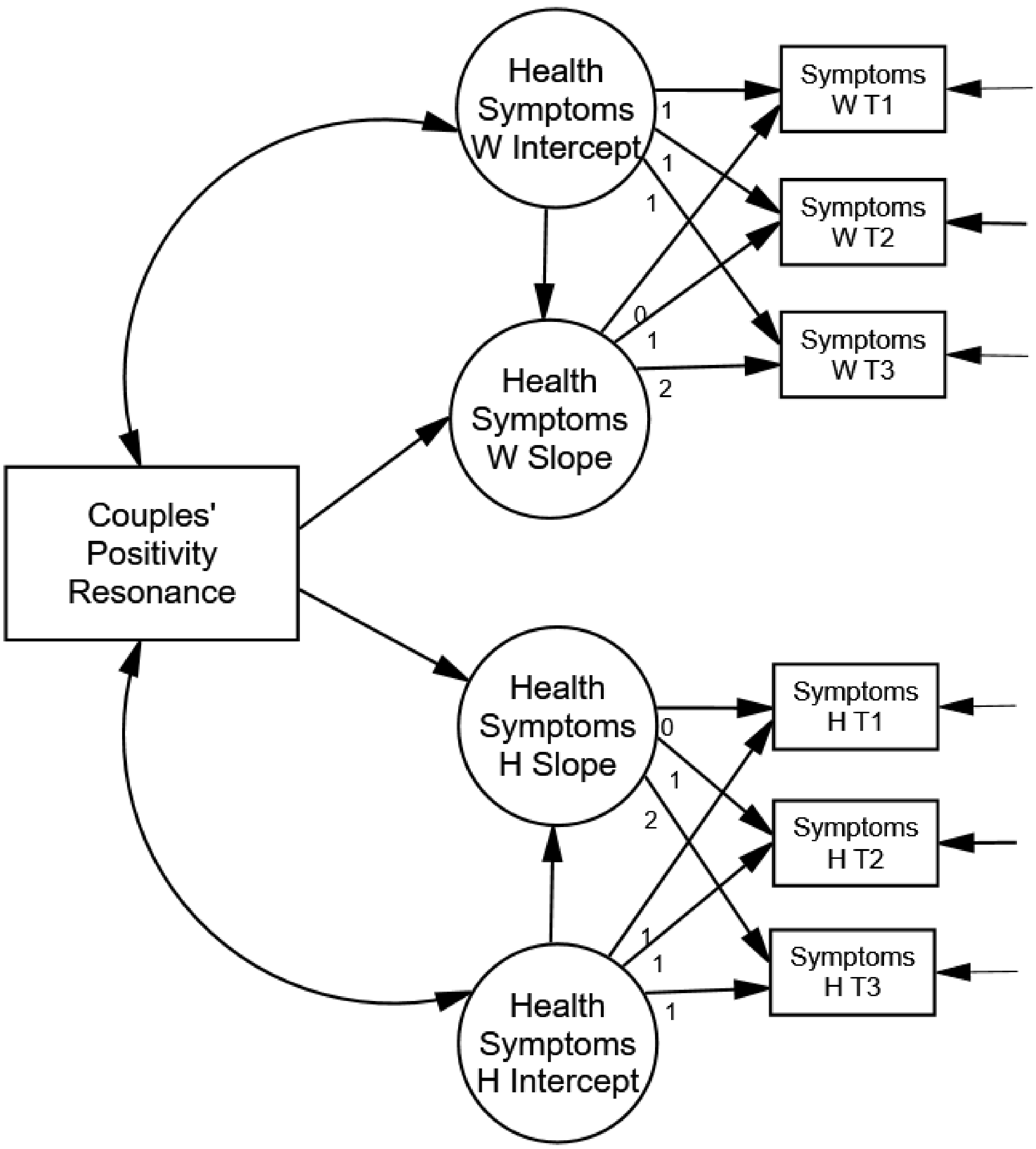
Health Trajectories. We constructed a series of latent growth curve models (LGMs; Olsen & Kenny, 2006) with latent intercepts and slopes of health trajectories for husbands and wives (separately) before constructing a dyadic LGM. To verify whether health trajectories followed a linear pattern of change, we compared the dyadic LGM to a dyadic no-growth model.

Longitudinal Health Predictions

We used LGMs to examine how couples' factor-scored latent positivity resonance at T1 predicted changes in both spouses' health symptoms over the ensuing 13 years (T1-T3). We constructed a dyadic linear LGM with both wives' and husbands' health symptoms that included: (a) intercepts (loadings of 1, 1, 1; indicating baseline levels of health symptoms at T1) and slopes (loadings of 0, 1, 2; indicating trajectories of health symptoms from T1 to T3) for both wives and husbands; (b) latent slopes regressed onto factor-scored latent positivity resonance at T1; (c) correlations between wives' and husbands' latent intercepts and factor-scored latent positivity resonance at T1; and (d) residual correlations within and across spouses' latent intercepts and slopes (to account for the shared variance between wives' and husbands' health symptoms). To test our hypotheses, we examined couples' factor-scored latent positivity resonance predicting wives' and husbands' health symptoms slopes, controlling for each spouse's own health symptom intercept (e.g., in the regression with factor-scored latent positivity resonance predicting wives' slope, wives' intercept was included as a covariate). **Figure 1** depicts the conceptual dyadic LGM.

Figure 1

Positivity Resonance and Health Symptoms: Conceptual Dyadic Latent Growth Curve Model



Note. Cross-spouse correlations between health symptoms intercepts and slope residuals as well as cross-spouse paths between health symptoms intercepts and slopes were also modeled but are omitted here for sake of clarity. Couples' positivity resonance was modeled as an observed variable, using factor scores to represent the latent construct that emerged from confirmatory factor analysis. W = Wives. H = Husbands. T1: 1989/90. T2: 1995/96. T3: 2001/02.

Gender Differences. To evaluate whether associations between couples' positivity resonance and individuals' health trajectories differed as a function of gender, we fit another dyadic LGM and constrained the effects of factor-scored positivity resonance on health symptoms slopes and the correlations between positivity resonance and health symptoms intercepts to be equal across wives and husbands. We used a chi-square likelihood-ratio test to compare the fit of the model with equality constraints to the initial dyadic LGM in which associations with positivity resonance were estimated freely (Jöreskog, 1971).

Covariates. Given well-established associations of socioeconomic status (Adler & Stewart, 2010) and health-related behaviors (McGinnis et al., 2002) with emotion and health, we sought to examine prospective associations between positivity resonance at T1 and changes in health symptoms over time by controlling for these potentially confounding influences. Consistent with our prior work (e.g., Haase et al., 2016), analyses controlled for sociodemographic characteristics (i.e., age, income, and education) and health-related behaviors (i.e., a composite of smoking, alcohol consumption, caffeine consumption, and lack of physical exercise) measured at T1 in the dyadic LGM. We also controlled for individually experienced positive affect to evaluate the relative influence of dyad-level positivity, versus individual-level positivity. These variables were included in the regressions with factor-scored positivity resonance predicting latent slopes, and we allowed for correlations between all covariates and latent intercepts. Next, to investigate the added value of couples' positivity resonance beyond self-reported marital satisfaction (which has already been linked with each of the dyad-level indicators of positivity resonance; Brown et al., 2021; Chen et al., 2020; Otero et al., 2019), we conducted additional LGM analyses following the same procedure as above, including wives' and husbands' marital satisfaction at T1 as independent variables in the corresponding regression analyses predicting latent slopes, and allowing for them to correlate with each other, with all covariates, and with the latent intercepts.

BIPR. Finally, to explore whether the holistic behavioral measure, BIPR, would make similar predictions for health trajectories to those made with the positivity resonance latent variable (indexed by factor scores) we repeated all longitudinal health analyses with BIPR (instead of factor-scored latent positivity resonance) as the independent variable of interest.

Mortality Predictions

We used Cox proportional hazard models to estimate the hazard ratios (HRs) and survival curves for mortality (Cox, 1972). Specifically, we used shared frailty models, which incorporate random effects to account for clustering of individuals within couples (Balan & Putter, 2020). The shared frailty terms were assumed to have a log-normal distribution. Mortality analyses proceeded in five steps. First, we assessed the proportional hazards assumption for all variables, which assumes that the log hazard is a linear, time-invariant (parametric) function of the predictors. In other words, it assumes the relative hazard remains constant over time for different levels of each independent variable (Therneau & Grambsch, 2000). We included a time interaction term for variables that violated this assumption (i.e., their effects on the HRs varied over time) in all subsequent models, using the time-transform functionality of *coxph* in the *survival* package (Therneau, 2020). Second, we tested whether factor-scored latent positivity resonance predicted mortality. Third, we tested whether gender moderated any observed effect of positivity resonance on mortality. Fourth, we examined whether factor-scored latent positivity resonance predicted mortality, independent of sociodemographic (i.e., age, gender, income, education), health (i.e., total health symptoms, health-related behaviors), affective (i.e., individually experienced positive affect), and relational (i.e., marital satisfaction) covariates.

Couples missing data for income (*n* = 1 couple) and individually experienced positive affect (*n* = 7 couples) were excluded from this step of analysis. Data for all other variables were complete. Finally, we again tested whether BIPR would make similar predictions for mortality to those made with factor-scored latent positivity resonance by repeating analyses with BIPR as the independent variable.

Results

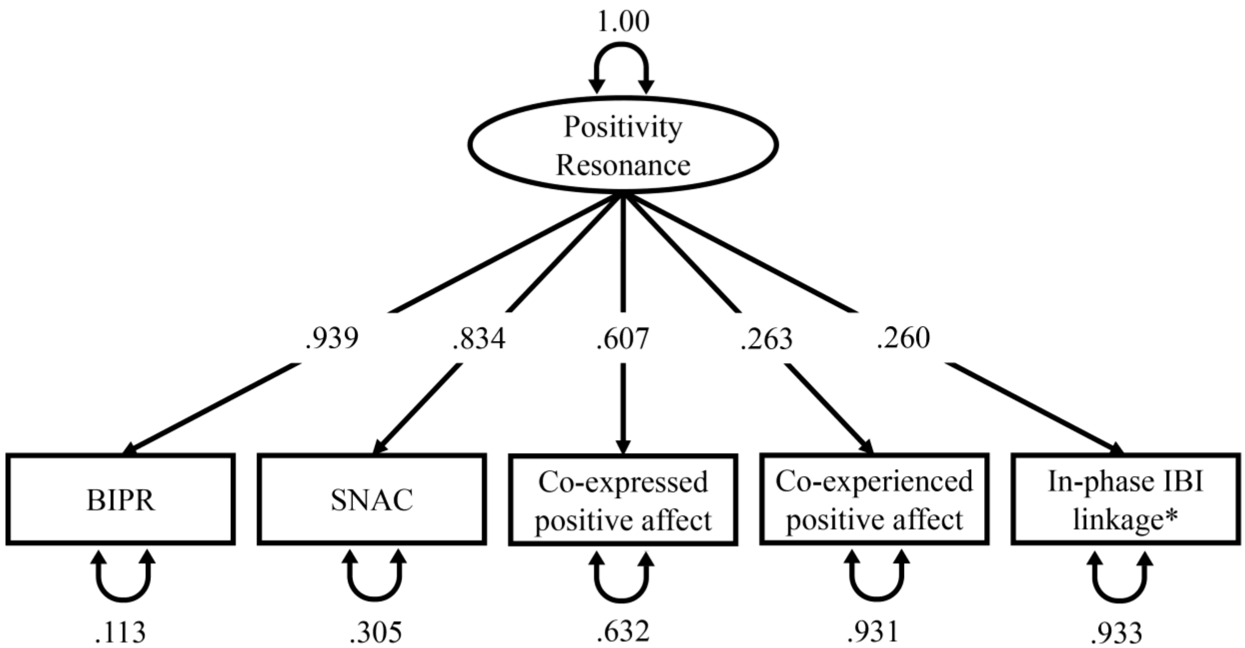
Preliminary Analyses: Construct Assessment

Measurement Model of Positivity Resonance (Hypothesis 1)

We used CFA to test a measurement model of couples' positivity resonance, modeled as a single latent factor indicated by BIPR, SNAC, co-expressed positive affect, co-experienced positive affect, and in-phase IBI linkage during moments of co-expressed positive affect. Supporting Hypothesis 1, the CFA for this model indicated excellent fit, $\chi^2(5) = 7.734$; $p = .172$; CFI = .987; SRMR = .036. We found that all five measured indicators of positivity resonance loaded significantly onto the latent variable (all *p*s < .05), with BIPR showing the highest loading and co-experienced positive affect and in-phase IBI linkage showing the lowest loadings. Because all loadings were significant, we did not exclude any indicators of positivity resonance from the latent factor. Standardized factor loadings and residual variances are presented in **Figure 2**.

Figure 2

Confirmatory Factor Analysis of Positivity Resonance



Note. All factor loadings were significant ($p < .05$). Curved arrows indicate standardized residual variances. *during co-expressed positive affect. BIPR = Behavioral Indicators of Positivity Resonance; SNAC = Synchronized Nonverbal Affiliation Cues; IBI = Inter-beat interval.

Latent Growth Curve Modeling of Health Trajectories

Separate linear LGMs of health symptoms showed good fit for wives and husbands, *p*s ≥ .366; CFI = 1.00; SRMR ≤ .021. In the wives' model, the residual variance of wives' health symptoms at T1 was negative and not significantly different from zero (δ = -.008, *p* = .945), thus, we fixed it to zero. A likelihood ratio test comparing an LGM with wives' T1 health symptoms residual variance fixed to zero to the initial LGM showed that the models were not significantly different ($\Delta\chi^2(1) = .004$, $p = .945$).

We proceeded to construct the dyadic LGM to model changes in both wives' and husbands' health symptoms, which also showed good fit, $\chi^2(7) = 9.705$; $p = .206$; CFI = .993; SRMR = .035. In the dyadic LGM, the only residual correlation that was significant was that between wives' latent intercept and slope (*r* = -.627, *p* = .027). Husbands' latent intercept and slope were not significantly correlated, nor were intercepts and slopes across spouses (all *p*s > .05). Nonetheless, we included correlations between wives' and husbands' latent slopes and intercepts to account for shared variance between wives' and husbands' health symptoms (akin to modeling the shared frailty in survival analyses), following established procedures (Olsen & Kenny, 2006).

We also compared the dyadic LGM to a dyadic no-growth model (Ferrer et al., 2004) using a likelihood-ratio test and found that the dyadic linear LGM had significantly better model fit ($\Delta\chi^2(9) = 18.471$, $p = .030$), thus, we continued to use the dyadic linear LGM in subsequent analyses. The dyadic LGM showed that the mean health symptom score for wives at T1 was 18.95 with a positive but non-significant (*p* = .455) change across the ensuing 13 years (T1-T3), whereas husbands' initial health symptom score at T1 was 13.44 with a positive slope that approached statistical significance (*p* = .062). Therefore, the dyadic LGM fit the expected pattern of change; the means of both wives' and husbands' latent slopes were positive, suggesting a linear increase in health symptoms over time (i.e., health worsened over time).

Positivity Resonance and Longitudinal Health Trajectories (Hypothesis 2)

We examined associations between couples' factor-scored positivity resonance at T1 and changes in health symptoms from T1-T3 using a series of dyadic LGMs. All models showed satisfactory fit (*p*s > .05 for χ^2 tests; CFI values > .95, SRMR values < .08).

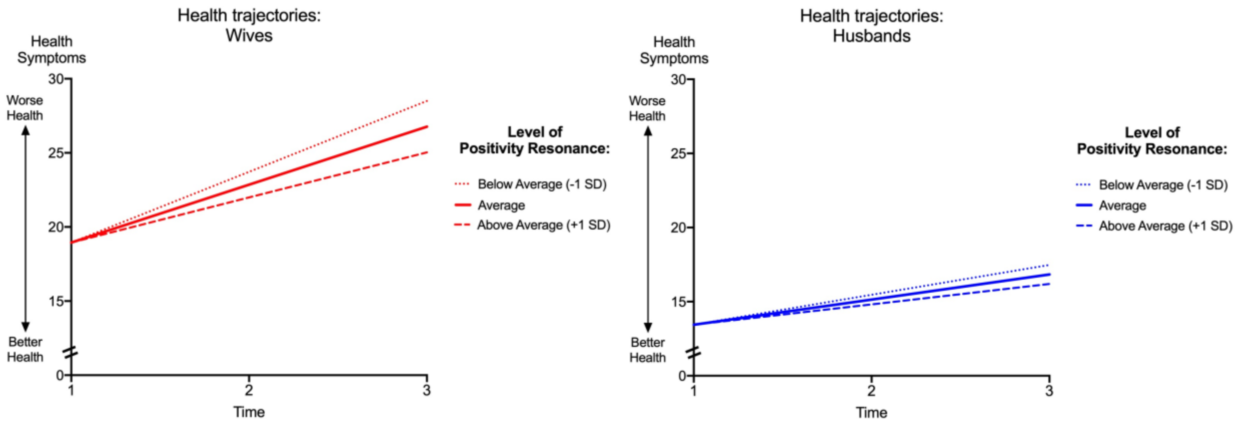
Predicting Health Trajectories

Couples' factor-scored latent positivity resonance at T1 was neither associated with wives' health symptoms intercept, *p* = .305, nor husbands' health symptoms intercept, *p* = .129. However, couples' factor-scored latent positivity resonance at T1 negatively predicted wives' health symptoms slope (*ß* = -.192, SE(*ß*) = .402, *p* = .028), adjusting for wives' health symptoms intercept. In other words, higher positivity resonance predicted less steep declines (i.e., better trajectories) in health symptoms over time for wives. Additionally, wives' health symptoms at T1 (i.e., health symptoms intercept) negatively predicted wives' health symptoms slope (*ß* = -.634, SE(*ß*) = .060, *p* = .002). These findings were not found for husbands' health symptoms slope (*ß* = -.110, SE(*ß*) = .366, *p* = .369). **Figure 3** shows the development of health symptoms over 13 years for those with low versus high positivity resonance at T1.[4]

[4] High values (> 3 standard deviations above the mean) exist at each timepoint. Given the nature of the data, we believe these are genuine scores that represent important sub-populations. For this reason, we chose to retain these values in our analyses. However, if we Winsorize these values (Tukey, 1962) by replacing them with the greatest observed value less than 3 standard deviations above the mean, we find the same pattern of significant results.

Figure 3

Wives' and Husbands' Health Trajectories Based on Levels of Positivity Resonance at Time 1



Note. Lines depict estimated health trajectories from dyadic latent growth curve model with factor-scored latent positivity resonance predicting health symptom slopes, controlling for health symptom intercepts. SD = standard deviation.

Gender Differences in Longitudinal Health Predictions

To test whether the effects of positivity resonance on health trajectories were, in fact, statistically different for wives and husbands, we constructed a dyadic LGM using the same parameters as above, except we constrained the effects of couples' factor-scored latent positivity resonance on health symptoms slopes to be equal across wives and husbands. We also constrained the correlations between positivity resonance and health symptoms intercepts to be equal across wives and husbands. In this model, couples' positivity resonance at T1 was not associated with health symptoms intercepts (across both wives and husbands), $p = .108$. However, couples' positivity resonance at T1 negatively predicted health symptoms slopes across both wives (*ß* = -.129) and husbands (*ß* = -.177, SE(*ß*) = .285, *p* = .045)[5], when adjusting for health symptoms intercepts. We then conducted a likelihood ratio test comparing the dyadic LGM with imposed equality constraints to the initial dyadic LGM (where effects are estimated freely across spouses) and found that the models were not significantly different ($\Delta\chi^2(2) = 1.275$, $p = .529$). This null effect suggests that the effects of positivity resonance on health do not differ significantly across genders. We proceeded to use the dyadic LGM with the aforementioned equality constraints in subsequent analyses, given that it emerged as the more parsimonious model.

Robustness When Adjusting for Covariates

Sociodemographic Characteristics, Health-Related Behaviors, and Individually Experienced Positive Affect. Adjusting for individuals' age, income, education, health-related behaviors, and individually experienced positive affect at T1, couples' positivity resonance at T1 was not associated with health symptoms intercepts, $p = .076$. When adjusting for these same covariates as well as health symptoms intercepts, couples' factor-scored latent positivity resonance at T1 continued to negatively predict health symptoms slopes (*ß* = -.149 for wives, *ß* = -.155 for husbands, SE(*ß*) = .282, *p* = .042). Among the covariates, only husbands' health symptoms intercept was associated with husbands' health symptoms slope (*ß* = -.383, SE(*ß*) = .069, *p* = .019).

Marital Satisfaction. Adjusting for all the above covariates and individuals' marital satisfaction at T1, couples' positivity resonance at T1 was not associated with health symptoms intercepts, $p = .063$. When adjusting for marital satisfaction as well as health symptoms

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[5] The variances of wives' and husbands' health symptoms slopes are different, which leads to differences in the standardized regression weights. We imposed constraints on the raw regression weights because of their lack of dependence on variances. Standardized effects will differ across wives and husbands, but standard errors and *p*-values will be equal, in the models with equality constraints.

intercepts, couples' factor-scored latent positivity resonance at T1 no longer significantly predicted health symptoms slopes ($ß$ = -.137 for wives, $ß$ = -.100 for husbands, SE($ß$) = .287, p = .170). Individuals' marital satisfaction also did not predict health symptoms slopes for wives nor husbands, ps > .133); though it was associated with health symptoms intercepts for both wives ($ß$ = -.284, SE($ß$) = 1.198, p = .001) and husbands ($ß$ = -.208, SE($ß$) = 0.699, p = .010).

BIPR and Longitudinal Health Trajectories

In the CFA conducted in the preliminary analyses, BIPR (Otero et al., 2019) was highly correlated with the latent positivity resonance factor and had the highest factor loading (λ = .94) among all of the indicators. To evaluate whether BIPR by itself would have similar predictive validity as did the latent factor (represented by factor scores), we repeated all longitudinal health analyses, replacing factor-scored latent positivity resonance with BIPR as the independent variable. Re-running the above dyadic LGMs with BIPR, the overall pattern of significance remained unchanged: BIPR-based positivity resonance at T1 continued to robustly predict the development of health symptoms over 13 years ($ß$ = -.129 for wives, $ß$ = -.178 for husbands, SE($ß$) = .272, p = .043). In sum, BIPR performed similarly to the latent factor of positivity resonance in making longitudinal health predictions (i.e., standardized regression coefficients for both measures were nearly equivalent, ~.20). Full analyses using BIPR to predict longitudinal health trajectories are presented in Online Supplemental Materials (see **Supplemental Results: BIPR and Longitudinal Health Trajectories** and **Supplemental Figure S1**).

Positivity Resonance and Longevity (Hypothesis 3)

Proportional Hazards Assumption

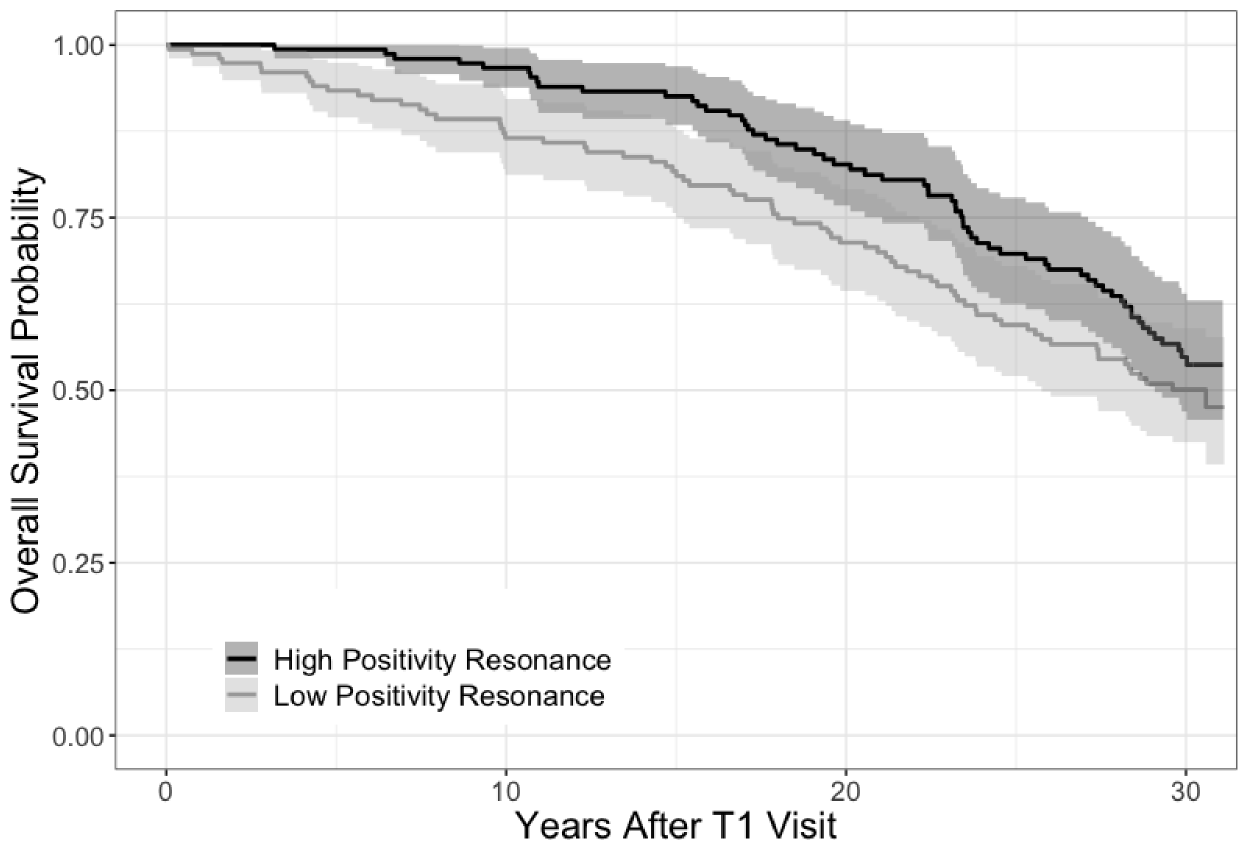
We assessed the proportional hazards assumption by fitting a Cox proportional hazard model with all independent variables; obtaining the Schoenfeld residuals (i.e., the observed values of the predictors minus their predicted values at each event time; Schoenfeld, 1982); and testing whether each variable exhibited a significant interaction with log-transformed time (Grambsch & Therneau, 1994). Analyses revealed that the effects of couples' factor-scored latent positivity resonance ($\chi^2(0.90) = 6.61$, $p = .009$) and individuals' age $\chi^2(0.92) = 7.28$, $p = .006$) on the Hazard Ratios (HRs) varied over time. A global test of non-proportionality showed that the overall model did not violate the proportional hazards assumption ($\chi^2(20.96) = 16.27$, $p = .752$).

Positivity Resonance Predicts Longevity

We tested whether couples' factor-scored latent positivity resonance (along with the interaction of positivity resonance with time) predicted mortality. As depicted in **Table 3** (Model 1), greater positivity resonance predicted increased longevity such that there was a 78% decrease in expected mortality for each standard deviation increase in couples' positivity resonance (see **Figure 4** for survival curves). In other words, greater positivity resonance was associated with a reduced risk of death. The interaction between positivity resonance and time also predicted mortality, such that the strength of the effect of positivity resonance on mortality became weaker, albeit slightly (i.e., the interaction effect HR = 1.00), over time.

Figure 4

Survival Curves for Positivity Resonance and Mortality



Note. Lines indicate estimated survival curves and shaded areas indicate 95% confidence intervals around the associated survival curves. Couples' factor-scored latent positivity resonance is depicted using a median split for display purposes only. T1 = Time 1.

Gender Differences in Mortality Predictions

We tested whether gender moderates the association between factor-scored latent positivity resonance and mortality by including positivity resonance (along with a positivity resonance by time interaction), gender, and an interaction term between positivity resonance and gender in a model predicting mortality. Greater factor-scored latent positivity resonance continued to predict increased longevity (HR = 0.21, 95% CI [0.089, 0.481], $p < .001$), as did female gender (HR = 0.56, 95% CI [0.385, 0.827], $p < .001$). The interaction term was not significant, $p = .600$, providing additional evidence that the longitudinal health effects of positivity resonance do not vary by gender. Therefore, we omitted the positivity resonance by gender interaction terms in subsequent models.

Robustness When Adjusting for Covariates

Sociodemographic Characteristics, Health-Related Behaviors, and Individually Experienced Positive Affect. Next, we examined whether positivity resonance predicted mortality, independent of age, gender, income, education, health symptoms, health-related behaviors, and individually experienced positive affect. As depicted in **Table 3** (Model 2), results revealed that greater factor-scored latent positivity resonance remained a significant predictor of increased longevity. Additional predictors of longevity included gender (being female decreased the risk of expected mortality by 51%); household income (one standard deviation increase in income decreased the risk of expected mortality by 22%); and total health symptoms (one standard deviation increase in symptoms increased the risk of mortality by 42%). The interaction between age and time was a significant predictor of mortality, such that the effect of age on mortality increased over time. Taken together, these findings are consistent with well-established risk factors for mortality from the literature, indicating that greater positivity resonance, being female, and greater income may independently protect against the risk of death, whereas greater age and greater health symptoms may independently increase the risk of death.

Marital Satisfaction. Adjusting for all the above covariates plus individuals' marital satisfaction at T1, greater factor-scored latent positivity resonance remained a significant predictor of decreased mortality, as depicted in **Table 3** (Model 3). We also found that greater marital satisfaction significantly predicted increased mortality (i.e., had a hazard ratio > 1); however, we caution against interpreting that association by noting that the zero-order relationship between marital satisfaction and mortality is not significant (see **Supplemental Table S2** for zero-order associations between each covariate and mortality). Given that the association between marital satisfaction and mortality emerges only when accounting for positivity resonance, it is possible that this association is driven by the variation in marital satisfaction that is unrelated to positivity resonance. It may be that some individuals whose relationships are characterized by lower positivity resonance (and thus have increased risk of mortality) overreported their marital satisfaction, perhaps to appear socially desirable. Noting that positivity resonance was assessed objectively in this study, whereas marital satisfaction was reported subjectively, is consistent with this speculation.

BIPR and Longevity

Again, we repeated all mortality analyses, replacing factor-scored latent positivity resonance with BIPR as the independent variable. Re-running the above Cox proportional hazard models with BIPR, the overall pattern of significance was consistent: BIPR at T1 continued to robustly predict mortality (HR = 0.21, 95% CI [0.085, 0.519], $p < .001$), including when adjusting for all covariates. The interaction between BIPR and time also significantly predicted mortality, such that the effects of BIPR on mortality decreased slightly over time (HR = 1.00, 95% CI [1.00, 1.00], *p* = .018). See **Supplemental Results: BIPR and Longevity**, **Supplemental Table S1**, and **Supplemental Figure S2**.

Table 3

Cox Regression HRs of Positivity Resonance and Covariates Predicting Mortality

	HRs and 95% CIs		
	Model 1	Model 2	Model 3
PosRes	0.22 [0.10, 0.51] ***	0.28 [0.12, 0.64] **	0.24 [0.10, 0.57] **
PosRes * time	1.00 [1.00, 1.00] **	1.00 [1.00, 1.00] *	1.00 [1.00, 1.00] *
Age	—	1.45 [0.80, 2.62]	1.40 [0.77, 2.52]
Age * time	—	1.00 [1.00, 1.00] **	1.00 [1.00, 1.00] **
Gender (1 = female)	—	0.50 [0.33, 0.75] ***	0.51 [0.34, 0.77] **
Household income	—	0.81 [0.65, 1.00]	0.78 [0.63, 0.97] *
Education	—	1.05 [0.84, 1.31]	1.10 [0.88, 1.37]
Health symptoms	—	1.32 [1.05, 1.65] *	1.41 [1.12, 1.78] **
Health-related behaviors	—	0.89 [0.73, 1.09]	0.92 [0.75, 1.13]
Individual[a] PA	—	1.00 [0.83, 1.21]	1.01 [0.83, 1.23]
Marital satisfaction	—	—	1.27 [1.01, 1.60] *

Note. HRs = hazard ratios. PosRes = factor-scored latent positivity resonance. PA = positive affect. [a]Individually experienced. *$p < .05$, **$p < .01$, ***$p < .001$. An asterisk (*) in the variable column indicates an interaction with time. A dash (—) indicates that the given variable was not included within the model. All variables are at the level of the individual, with the exceptions of factor-scored latent positivity resonance (and its interaction with time) and household income. All variables were measured at the first timepoint.

Discussion

In the present study, we tested whether positivity resonance (measured both as a multimodal latent factor and through a holistic behavioral coding system) predicts 13-year health trajectories and longevity. A measurement model comprised of novel, dyad-level measures of positivity resonance, each objectively assessed, had excellent fit, and thereby supported our first hypothesis that the observed scores for these variables are influenced by an emergent, latent construct (i.e., positivity resonance). Latent growth curve modeling showed some evidence that both wives and husbands exhibited increases in health symptoms over time. Results also supported our second hypothesis that greater positivity resonance (latent factor or BIPR) predicts better health trajectories (i.e., fewer increases over time in health symptoms). This association was initially found for wives only, although we did not find evidence that there was a statistically significant difference in the effects of positivity resonance on health trajectories across wives and husbands. When equality constraints were imposed, positivity resonance significantly predicted health trajectories across both spouses, and this model emerged as more parsimonious than the model in which the effects of positivity resonance were estimated freely. However, the association between positivity resonance and health trajectories was not robust when accounting for marital satisfaction, which was somewhat unsurprising given high multicollinearity among positivity resonance and marital satisfaction (i.e., features of positivity resonance have been consistently positively correlated with marital satisfaction in this sample; Brown et al., 2021; Chen et al., 2020; Otero et al., 2019).

In another set of analyses, we found that greater positivity resonance (latent factor or BIPR) predicted greater longevity (i.e., decreased risk of mortality), supporting our third hypothesis. Again, gender did not moderate this association; and further, this association was independent of self-reported marital satisfaction. Moreover, all associations (13-year health trajectories and longevity) were robust when accounting for sociodemographic characteristics (i.e., age, income, education), health-related behaviors (i.e., smoking, alcohol consumption, caffeine consumption, and lack of physical exercise), and individually experienced positive affect (e.g., the number of seconds in which wives reported feeling positive while husbands did not). Results also indicated an interaction between positivity resonance and time, such that the effects of positivity resonance on longevity were slightly attenuated over time. We speculate that this time-related reduction in impact may reasonably reflect that other risk factors show time-related increases in impact over time, like age, that may ultimately mitigate the long-term protective effects of resilience factors like positivity resonance. Nonetheless, the robust associations between positivity resonance and longitudinal health and longevity are particularly striking given that these measures were drawn from one 15-minute conversation that occurred over a decade (in the case of health symptoms) and up to three decades (in the case of longevity) earlier. Taken together, these findings offer support for Positivity Resonance Theory, and suggest that the novel group-level affective construct of positivity resonance may be an important predictor of the long-term health and longevity. Akin to individuals' day-to-day health habits of participating in physical exercise and eating nutritious food, their day-to-day habits of cultivating positivity resonance with others may also function as positive health behaviors (Fredrickson, 2016).

Construct Validation

Our results provide preliminary evidence validating the existence of a multimodal positivity resonance construct that is indicated by dyad-level experiential, behavioral, and physiological measures. The factor loadings from the CFA provide insight into the degree to which the various measured indicators of positivity resonance are represented by the latent factor. Given that BIPR is a holistic measure that encompasses multiple theorized components (rather than one defining feature) of positivity resonance, it makes sense that BIPR has the highest factor loading. Co-experienced positive affect, followed by in-phase IBI linkage during co-expressed positive affect, showed the smallest (albeit significant) associations with the latent factor, consistent with previous work showing that physiological responses tend to show less coherence with other domains of emotional responses (i.e., subjective experience, behavior; Mauss et al., 2005; Mauss et al., 2004). Nevertheless, all measures had significant factor loadings, supporting the hypothesis that these key features – shared positive affect, caring nonverbal synchrony, and biological synchrony – reflect a collective-level latent factor of positivity resonance.

Wives and Husbands

Our initial test of Hypothesis 2 suggested gender-specific effects, in that couples' positivity resonance predicted wives', but not husbands', health trajectories over 13 years. Considering that women tend to have larger social networks (Phillipson, 1997) and receive more social support (Turner & Marino, 1994; Umberson, 1992) than men, they likely have more social interactions than do men. Further, women may also *cultivate* more positivity resonance in such interactions, given that they tend to smile and laugh more than men (Bachorowski et al., 2001; LaFrance et al., 2003), which, in turn, is known to elicit more positive affect in their interaction partners (Bachorowski & Owren, 2001; Niedenthal et al., 2010). If so, longitudinal associations between positivity resonance and health may be more likely for wives, who conceivably benefit from a higher "dose" of positivity resonance, than for their husbands.

Another plausible explanation for this initial finding could be that men often underreport their health symptoms, perhaps in part due to social roles that influence willingness to disclose and communicate distress (Barsky et al., 2001; Kroenke & Spitzer, 1998). This gender-specific tendency may be a potential source of bias in self-reports that may have artificially dampened the mean health symptoms scores for the husbands (see **Figure 3**, which reveals husbands' self-reported health symptoms to be significantly lower than that of wives across all timepoints), which may have influenced our analysis of the association between positivity resonance and health trajectories in men.

Nevertheless, when we fixed the effects of positivity resonance on health to be equal across husbands and wives, we found that positivity resonance significantly predicted health trajectories across both spouses, and further, this model emerged as the more parsimonious option. Additionally, we found evidence that the effects of positivity resonance on health extend beyond questionnaire data to a more objective, valid outcome – mortality. Indeed, our results supported both of our hypotheses, that positivity resonance predicts longitudinal health trajectories and longevity, across both wives and husbands. Therefore, we would expect to see similar results across other types of relationships and genders beyond the heterosexual, presumably cisgender cohort examined here. Future research is needed, however, to examine positivity resonance in other types of dyads and relationship contexts.

Theoretical and Practical Implications

The present work is grounded in theories of affective science. Principally, this study is motivated by the Positivity Resonance Theory of co-experienced positive affect, which proposes that (a) shared positive affect, caring nonverbal synchrony, and biological synchrony reflect moments of positivity resonance; and (b) together, these responses promote health and well-being over time (Fredrickson, 2013, 2016). Positivity Resonance Theory builds on the idea of emotion coherence – that emotions involve coordinated changes across behavioral, experiential, and physiological response systems (Ekman, 1992; Levenson, 1994) – and extends it to dyad- and group-level changes in emotion. Recent work with the present dataset shows that in-phase physiological linkage is greatest during seconds in which both partners are simultaneously expressing or experiencing positive affect (Chen et al., 2020), and additional work demonstrates that greater coherence between subjective experience and physiology is associated with greater well-being (Brown et al., 2020). Here, we show positive covariation of dyad-level emotional responses within a broader temporal unit (i.e., the entire conversation). Therefore, this collection of findings lends support to Positivity Resonance Theory and have the potential to support emotion coherence theory. Notwithstanding the rich history of emotion coherence, we acknowledge that the present analytic approach does not provide the same degree of temporal precision (e.g., moment-by-moment) with which foundational studies in this area have been conducted (e.g., Mauss et al., 2005; Rosenberg & Ekman, 1994).

Adding to the affective science methods literature, we offer additional support for the holistic coding system, BIPR (Otero et al., 2019). BIPR's high correlations with the latent positivity resonance factor as well as with all of the observed indicators (see **Table 1**) demonstrate the construct validity of this relatively new, dyad-level behavioral coding system (Otero et al., 2019). Further, longitudinal associations with 13-year health trajectories and longevity were nearly identical across the BIPR measure and the latent positivity resonance factor. Evaluating positivity resonance through multiple, dyad-level behavioral, experiential, and biological measures enabled us to affirm their theorized covariance through CFA. However, future researchers seeking to measure high-quality moments of positive interpersonal connection may prefer to measure BIPR alone, rather than the full latent factor, which would reduce demands on time and resources while still making similar health predictions. Indeed, BIPR coding is less time-consuming (e.g., only two weeks of training were needed, and two viewings of 30-second video records; Otero et al., 2019) than many widely used behavioral coding systems (e.g., SPAFF).

Affective scientists should also note that our findings indicate socially-shared positive affect may be more powerful in promoting long-term health and longevity than is individually experienced positive affect. At the same time, relationship scientists should note that social relationships may be especially effective in promoting good health outcomes when shared positive affect, nonverbal care, and synchrony are present. The presence of these features may be particularly important for promoting health during moments of conflict (i.e., the context in which they were measured in the present study), given that positive affect can “undo” the cardiovascular activation produced by negative affect, an effect that has been shown both for negative affect induced within tightly controlled laboratory studies (Fredrickson & Levenson, 1998; Tugade & Fredrickson, 2004) and for negative affect that arises during conflictual conversations between husbands and wives (i.e., as in the present sample; Yuan et al., 2010). This “undo” effect of positive affect likely also extends to co-experienced positive affect (c.f. Prinzing et al., 2020), and may thus function to mitigate risks for cardiovascular disease. Nevertheless, co-experienced positive affect has been found to predict marital satisfaction in other conversational contexts (e.g., discussion of a pleasant topic; Brown et al., 2021); however, additional work is needed to clarify whether this would extend to longitudinal health and longevity.

On the one hand, social interactions that are marked by positivity resonance likely support the formation and maintenance of close relationships, as is consistently evidenced by positive associations between positivity resonance (holistic and individual measures) and marital satisfaction (Brown et al., 2021; Chen et al., 2020; Lai et al., in prep; Otero et al., 2019). On the other hand, pre-existing relationship satisfaction is likely to facilitate more frequent emergence of positivity resonance. Associations between positivity resonance and marital satisfaction are likely bidirectional. Although the association between positivity resonance and health trajectories was not robust when accounting for marital satisfaction, the association with longevity was found to be independent of self-reported marital satisfaction. It may be that associations with health trajectories were relatively weaker due to attrition (i.e., couples with lower positivity resonance at T1 had higher dropout rates at T3) or common method variance (i.e., health and marital satisfaction were both measured via self-report questionnaire), whereas the association with longevity was relatively stronger for the same reason (i.e., individuals with lower positivity resonance were more likely to pass away, and there was no common method variance between marital satisfaction and mortality). Nevertheless, in addition to promoting relationship satisfaction, positivity resonance may also play a role in other relationship functions such as partner responsiveness (a feature of positivity resonance; Reis, 2014), capitalization (Gable & Reis, 2010), and expressed appreciation (Algoe et al., 2013), all of which may serve as springboards for positivity resonance.

Strengths and Limitations

The present study had numerous methodological strengths, including (a) utilizing a longitudinal dataset, enabling detection of health effects that develop over time; (b) measuring positivity resonance through multiple, objective dyad-level methods, which are less vulnerable to inflated associations with self-reported health through common method variance (c.f. Kelley, 1992); (c) examining longitudinal health through two domains, including 13-year health trajectories and longevity over an even longer time interval; (d) adjusting for sociodemographic characteristics and health-related behaviors known to influence health; (e) testing the predictive validity of positivity resonance, independent of individually experienced positive affect and marital satisfaction; and (f) demonstrating the predictive validity of BIPR, a parsimonious measure of positivity resonance that can be readily implemented by future researchers.

There are also several limitations to note. Although in 1989 the CMI was considered among the best health measures in the field (e.g., Aldwin et al., 2001) and there is a large body of research supporting its validity (Weaver et al., 1980), our measure of health symptoms was obtained via self-report rather than from more direct health measures (e.g., BMI, health care utilization). An additional limitation includes the potential generalizability of the present study, which utilized data from a racially and ethnically homogenous sample of heterosexual married couples in the San Francisco Bay Area in the 1990s. It remains to be determined whether these findings extend to other types of relationships (e.g., friends, homosexual couples, newlyweds, parent-child dyads), other demographic groups, or to couples outside of this geographical region or time period. It is also important to acknowledge that this sample consisted of people who lived through times when gender roles were changing radically and that other generations might show different findings related to gender. Additionally, this sample only included couples where marital satisfaction scores of individual spouses fell within 20 points of one another, and thus results may not generalize to couples who have larger discrepancies in their marital satisfaction levels.

It also bears mentioning that while the CFA of positivity resonance includes measures of all its defining features, the results do not preclude the possibility that another factor structure of positivity resonance exists. That is, while the shared variance of these measures does reflect an underlying, latent factor, there may be other ways of measuring positivity resonance (not captured here) that could strengthen the assessment of the factor. Additionally, given that the absence of positivity resonance does not imply the presence of negative affect (and vice versa), future researchers should evaluate whether shared negative affect, or negativity resonance, exhibits unique associations with health and longevity. Finally, our study was designed to evaluate the longitudinal associations between positivity resonance measured at baseline and changes in health symptoms over time. Future longitudinal studies should evaluate bidirectional associations to test the possibility of upward spirals between positivity resonance and health over time (see Fredrickson & Joiner, 2018).

Conclusion

The current study is the first comprehensive, multimodal assessment of positivity resonance at the dyadic level. Results lend support for our hypotheses that positivity resonance shows prospective associations with long-term health trajectories and longevity, which were observed to be independent of individually experienced positive affect. Conceptually, the high covariance observed among the defining features of positivity resonance offer further support for the Positivity Resonance Theory of co-experienced positive affect (Fredrickson, 2016). Methodologically, BIPR, the holistic behavioral coding measure, performed on par with the more comprehensive latent factor of positivity resonance in its health and longevity predictions, and may emerge as the most useful tool for researchers working in this area. The present findings also contribute to scientific understanding of interpersonal emotions and behaviors that lay the foundation for long-term health and longevity. Future research should explore specific biological and/or behavioral pathways through which positivity resonance is linked with health and longevity, as well as whether the findings extend to other types of dyadic relationships. Considering mounting evidence underscoring the importance of high-quality social connections in daily life, positivity resonance should be evaluated as a potential intervention target to determine if it can lead to improvements in health and well-being throughout society (c.f. Zhou et al., in press).

References

Adler, N. E., & Stewart, J. (2010). Health disparities across the lifespan: meaning, methods, and mechanisms. *Annals of the New York Academy of Sciences*, *1186*(1), 5-23. https://doi.org/10.1111/j.1749-6632.2009.05337.x

Aldwin, C. M., Spiro, A., Levenson, M. R., & Bossé, R. (1989). Longitudinal findings from the normative aging study: I. Does mental health change with age? *Psychology and Aging*, *4*(3), 295-306. https://doi.org/10.1037/0882-7974.4.3.295

Aldwin, C. M., Spiro, A., Levenson, M. R., & Cupertino, A. P. (2001). Longitudinal findings from the normative aging study: III. Personality, individual health trajectories, and mortality. *Psychology and Aging*, *16*(3), 450-465. https://doi.org/10.1037/0882-7974.16.3.450

Algoe, S. B. (2019). Positive interpersonal processes. *Current directions in psychological science*, *28*(2), 183-188. https://doi.org/10.1177/0963721419827272

Algoe, S. B., Fredrickson, B. L., & Gable, S. L. (2013). The social functions of the emotion of gratitude via expression. *Emotion*, *13*(4), 605-609. https://doi.org/10.1037/a0032701

Anderson, C., Keltner, D., & John, O. P. (2003). Emotional convergence between people over time. *Journal of Personality and Social Psychology*, *84*(5), 1054-1068. https://doi.org/10.1037/0022-3514.84.5.1054

Bachorowski, J.-A., & Owren, M. J. (2001). Not all laughs are alike: Voiced but not unvoiced laughter readily elicits positive affect. *Psychological science*, *12*(3), 252-257. https://doi.org/10.1111/1467-9280.00346

Bachorowski, J.-A., Smoski, M. J., & Owren, M. J. (2001). The acoustic features of human laughter. *The Journal of the Acoustical Society of America*, *110*(3), 1581-1597. https://doi.org/10.1121/1.4778613

Balan, T. A., & Putter, H. (2020). A tutorial on frailty models. *Statistical Methods in Medical Research*, *29*(11), 3424-3454. https://doi.org/10.1177/0962280220921889

Barsky, A. J., Peekna, H. M., & Borus, J. F. (2001). Somatic symptom reporting in women and men. *Journal of general internal medicine*, *16*(4), 266-275. https://doi.org/10.1046/j.1525-1497.2001.00229.x

Baucom, D. H., Notarius, C. I., Burnett, C. K., & Haefner, P. (1990). Gender differences and sex-role identity in marriage. In F. D. Fincham & T. N. Bradbury (Eds.), *The psychology of marriage: Basic issues and applications* (pp. 150-171). Guilford Press.

Beach, S. R. (2014). The couple and family discord model of depression: Updates and future directions. In C. R. Agnew & S. C. South (Eds.), *Interpersonal relationships and health: Social and clinical psychological mechanisms* (pp. 133-155). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199936632.003.0007

Beach, S. R., Fincham, F. D., & Katz, J. (1998). Marital therapy in the treatment of depression: Toward a third generation of therapy and research. *Clinical psychology review*, *18*(6), 635-661. https://doi.org/10.1016/s0272-7358(98)00023-3

Bernieri, F. J., Reznick, J. S., & Rosenthal, R. (1988). Synchrony, pseudosynchrony, and dissynchrony: measuring the entrainment process in mother-infant interactions. *Journal of Personality and Social Psychology*, *54*(2), 243. https://doi.org/10.1037/0022-3514.54.2.243

Bibevski, S., & Dunlap, M. E. (2011). Evidence for impaired vagus nerve activity in heart failure. *Heart failure reviews*, *16*(2), 129-135. https://doi.org/10.1007/s10741-010-9190-6

Bloch, L., Haase, C. M., & Levenson, R. W. (2014). Emotion regulation predicts marital satisfaction: More than a wives' tale. *Emotion*, *14*(1), 130. https://doi.org/10.1037/a0034272

Bolanos, F., Herbeck, D., Christou, D., Lovinger, K., Pham, A., Raihan, A., Rodriguez, L., Sheaff, P., & Brecht, M.-L. (2012). Using Facebook to maximize follow-up response rates in a longitudinal study of adults who use methamphetamine. *Substance abuse: research and treatment*, *6*, SART. S8485. https://doi.org/10.4137/SART.S8485

Bowlby, J. (1969). *Attachment and Loss* (Vol. 1: Attachment). Basic Books.

Bradley, M. M., Codispoti, M., Sabatinelli, D., & Lang, P. J. (2001). Emotion and motivation II: sex differences in picture processing. *Emotion*, *1*(3), 300. https://doi.org/10.1037/1528-3542.1.3.300

Brodman, K., Erdmann, A. J., & Wolff, H. G. (1949). *Cornell medical index health questionnaire: Manual*. Cornell University Medical College.

Brody, L., & Hall, J. (2000). Sex and emotion. In M. Lewis & J. Haviland-Jones (Eds.), *Handbook of emotions* (2nd ed., pp. 325-414). The Guilford Press.

Brown, C. L., Chen, K.-H., Wells, J. L., Otero, M. C., Connelly, D. E., Levenson, R. W., & Fredrickson, B. L. (2021). Shared emotions in shared lives: Moments of co-experienced affect, more than individually experienced affect, linked to relationship quality. *Emotion*. https://doi.org/10.1037/emo0000939

Brown, C. L., & Fredrickson, B. L. (2021). Characteristics and consequences of co-experienced positive affect: understanding the origins of social skills, social bonds, and caring, healthy communities. *Current Opinion in Behavioral Sciences*, *39*, 58-63. https://doi.org/https://doi.org/10.1016/j.cobeha.2021.02.002

Brown, C. L., Van Doren, N., Ford, B. Q., Mauss, I. B., Sze, J. W., & Levenson, R. W. (2020). Coherence between subjective experience and physiology in emotion: Individual differences and implications for well-being. *Emotion*, *20*(5), 818. https://doi.org/10.1037/emo0000579

Burgess, E. W., Locke, H. J., & Thomes, M. M. (1971). *The family: From traditional to companionship*. Van Nostrand Reinhold.

Butler, E. A. (2017). Emotions are temporal interpersonal systems. *Current Opinion in Psychology*, *17*, 129-134. https://doi.org/10.1016/j.copsyc.2017.07.005

Candy, S. G., Troll, L. E., & Levy, S. G. (1981). A developmental exploration of friendship functions in women. *Psychology of Women Quarterly*, *5*(3), 456-472. https://doi.org/10.1111/j.1471-6402.1981.tb00586.x

Carr, D., Freedman, V. A., Cornman, J. C., & Schwarz, N. (2014). Happy marriage, happy life? Marital quality and subjective well-being in later life. *Journal of marriage and family*, *76*(5), 930-948. https://doi.org/10.1111/jomf.12133

Carstensen, L. L., Gottman, J. M., & Levenson, R. W. (1995). Emotional behavior in long-term marriage. *Psychology and Aging*, *10*(1), 140-149. https://doi.org/10.1037/0882-7974.10.1.140

Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously: A theory of socioemotional selectivity. *American Psychologist*, *54*(3), 165-181. https://doi.org/doi.org/10.1037/0003-066x.54.3.165

Catalino, L. I., & Fredrickson, B. L. (2011). A Tuesday in the life of a flourisher: The role of positive emotional reactivity in optimal mental health. *Emotion*, *11*(4), 938-950. https://doi.org/10.1037/a0024889

Chen, K.-H., Brown, C. L., Wells, J. L., Rothwell, E. S., Otero, M. C., Fredrickson, B. L., & Levenson, R. W. (2020). Physiological linkage during moments of shared positive and shared negative emotion. *Journal of Personality and Social Psychology*. https://doi.org/10.1037/pspi0000337

Chida, Y., & Steptoe, A. (2008). Positive psychological well-being and mortality: a quantitative review of prospective observational studies. *Psychosomatic Medicine*, *70*(7), 741-756. https://doi.org/10.1097/psy.0b013e31818105ba

Coan, J. A., & Gottman, J. M. (2007). The specific affect (SPAFF) coding system. In J. A. Coan & J. J. B. Allen (Eds.), *Handbook of emotion elicitation and assessment* (pp. 106-123). Oxford University Press.

Cox, D. R. (1972). Regression models and life-tables. *Journal of the Royal Statistical Society: Series B (Methodological)*, *34*(2), 187-202. https://doi.org/10.1111/j.2517-6161.1972.tb00899.x

Diener, E., & Chan, M. Y. (2011). Happy people live longer: Subjective well-being contributes to health and longevity. *Applied Psychology: Health and Well-Being*, *3*(1), 1-43. https://doi.org/10.1037/e675972011-001

DiStefano, C., Zhu, M., & Mindrila, D. (2009). Understanding and using factor scores: Considerations for the applied researcher. *Practical Assessment, Research, and Evaluation*, *14*(1), 20. https://doi.org/10.7275/da8t-4g52

Duncan, S. C., Duncan, T. E., & Strycker, L. A. (2006). Alcohol use from ages 9 to 16: A cohort-sequential latent growth model. *Drug and alcohol dependence*, *81*(1), 71-81. https://doi.org/10.1016/j.drugalcdep.2005.06.001

Ekman, P. (1992). An argument for basic emotions. *Cognition & Emotion*, *6*(3-4), 169-200. https://doi.org/10.1080/02699939208411068

Engoren, M. C., Habib, R. H., Zacharias, A., Schwann, T. A., Riordan, C. J., & Durham, S. J. (2002). Effect of blood transfusion on long-term survival after cardiac operation. *The Annals of thoracic surgery*, *74*(4), 1180-1186. https://doi.org/10.1016/s0003-4975(02)03766-9

Feeney, B. C., & Collins, N. L. (2015). A new look at social support: A theoretical perspective on thriving through relationships. *Personality and Social Psychology Review*, *19*(2), 113-147. https://doi.org/10.1177/1088868314544222

Feldman, R. (2015). Sensitive periods in human social development: New insights from research on oxytocin, synchrony, and high-risk parenting. *Development and psychopathology*, *27*(2), 369-395. https://doi.org/10.1017/s0954579415000048

Feldman, R., Gordon, I., Schneiderman, I., Weisman, O., & Zagoory-Sharon, O. (2010). Natural variations in maternal and paternal care are associated with systematic changes in oxytocin following parent-infant contact. *Psychoneuroendocrinology*, *35*(8), 1133-1141. https://doi.org/10.1016/j.psyneuen.2010.01.013

Ferrer, E., Hamagami, F., & McArdle, J. J. (2004). Modeling latent growth curves with incomplete data using different types of structural equation modeling and multilevel software. *Structural equation modeling*, *11*(3), 452-483. https://doi.org/10.1207/s15328007sem1103_8

Field, D., & Minkler, M. (1988). Continuity and change in social support between young-old and old-old or very-old age. *Journal of gerontology*, *43*(4), P100-P106. https://doi.org/10.1093/geronj/43.4.p100

Finkelstein, D. M. (1986). A proportional hazards model for interval-censored failure time data. *Biometrics*, *42*(4), 845-854. https://doi.org/10.2307/2530698

Fredrickson, B. L. (1998). What good are positive emotions? *Review of general psychology*, *2*(3), 300-319. https://doi.org/10.1037/1089-2680.2.3.300

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American Psychologist*, *56*(3), 218. https://doi.org/10.1037/0003-066x.56.3.218

Fredrickson, B. L. (2013). *Love 2.0: How our supreme emotion affects everything we feel, think, do, and become*. Hudson Street Press/Penguin.

Fredrickson, B. L. (2016). Love: Positivity resonance as a fresh, evidence-based perspective on an age-old topic. In L. F. Barrett, M. Lewis, & J. Haviland-Jones (Eds.), *Handbook of emotions* (4th ed., pp. 847-858). Guilford Press.

Fredrickson, B. L., Cohn, M. A., Coffey, K. A., Pek, J., & Finkel, S. M. (2008). Open hearts build lives: positive emotions, induced through loving-kindness meditation, build consequential personal resources. *Journal of Personality and Social Psychology*, *95*(5), 1045-1062. https://doi.org/10.1037/a0013262

Fredrickson, B. L., & Joiner, T. (2018). Reflections on positive emotions and upward spirals. *Perspectives on Psychological Science*, *13*(2), 194-199. https://doi.org/10.1177/1745691617692106

Fredrickson, B. L., & Levenson, R. W. (1998). Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. *Cognition & Emotion*, *12*(2), 191-220. https://doi.org/10.1080/026999398379718

Gable, S. L., Gonzaga, G. C., & Strachman, A. (2006). Will you be there for me when things go right? Supportive responses to positive event disclosures. *Journal of Personality and Social Psychology*, *91*(5), 904. https://doi.org/10.1037/0022-3514.91.5.904

Gable, S. L., Gosnell, C. L., Maisel, N. C., & Strachman, A. (2012). Safely testing the alarm: Close others' responses to personal positive events. *Journal of Personality and Social Psychology*, *103*(6), 963. https://doi.org/10.1037/a0029488

Gable, S. L., & Reis, H. T. (2010). Good news! Capitalizing on positive events in an interpersonal context. In *Advances in experimental social psychology* (Vol. 42, pp. 195-257). Elsevier.

Gable, S. L., Reis, H. T., Impett, E. A., & Asher, E. R. (2004). What do you do when things go right? The intrapersonal and interpersonal benefits of sharing positive events. *Journal of Personality and Social Psychology*, *87*(2), 228-245. https://doi.org/10.1037/0022-3514.87.2.228

Glenn, N. D., & Weaver, C. N. (1981). The contribution of marital happiness to global happiness. *Journal of Marriage and the Family*, 161-168. https://doi.org/10.2307/351426

Goldenberg, A., Garcia, D., Halperin, E., & Gross, J. J. (2020). Collective emotions. *Current directions in psychological science*, *29*(2), 154-160. https://doi.org/10.1177/0963721420901574

Gonzaga, G. C., Keltner, D., Londahl, E. A., & Smith, M. D. (2001). Love and the commitment problem in romantic relations and friendship. *Journal of Personality and Social Psychology*, *81*(2), 247-262. https://doi.org/10.1037//0022-3514.81.2.247

Gottman, J. M. (1991). Predicting the longitudinal course of marriages. *Journal of marital and Family Therapy*, *17*(1), 3-7. https://doi.org/10.1111/j.1752-0606.1991.tb00856.x

Gottman, J. M., & Levenson, R. W. (1985). A valid procedure for obtaining self-report of affect in marital interaction. *Journal of consulting and clinical psychology*, *53*(2), 151-160. https://doi.org/10.1037/0022-006x.53.2.151

Gottman, J. M., & Levenson, R. W. (1986). Assessing the role of emotion in marriage. *Behavioral Assessment*, *8*(1), 31-48.

Gottman, J. M., & Levenson, R. W. (1992). Marital processes predictive of later dissolution: behavior, physiology, and health. *Journal of Personality and Social Psychology*, *63*(2), 221-233. https://doi.org/10.1037/0022-3514.63.2.221

Grambsch, P. M., & Therneau, T. M. (1994). Proportional hazards tests and diagnostics based on weighted residuals. *Biometrika*, *81*(3), 515-526. https://doi.org/10.1093/biomet/81.3.515

Gruber, J., Mauss, I. B., & Tamir, M. (2011). A dark side of happiness? How, when, and why happiness is not always good. *Perspectives on Psychological Science*, *6*(3), 222-233. https://doi.org/10.1177/1745691611406927

Haase, C. M., Holley, S. R., Bloch, L., Verstaen, A., & Levenson, R. W. (2016). Interpersonal emotional behaviors and physical health: A 20-year longitudinal study of long-term married couples. *Emotion*, *16*(7), 965-977. https://doi.org/10.1037/a0040239

Haase, C. M., Saslow, L. R., Bloch, L., Saturn, S. R., Casey, J. J., Seider, B. H., Lane, J., Coppola, G., & Levenson, R. W. (2013). The 5-HTTLPR polymorphism in the serotonin transporter gene moderates the association between emotional behavior and changes in marital satisfaction over time. *Emotion*, *13*(6), 1068-1079. https://doi.org/10.1037/a0033761

Harker, L., & Keltner, D. (2001). Expressions of positive emotion in women's college yearbook pictures and their relationship to personality and life outcomes across adulthood. *Journal of Personality and Social Psychology*, *80*(1), 112-124. https://doi.org/10.1037/0022-3514.80.1.112

Hasson, U., Nir, Y., Levy, I., Fuhrmann, G., & Malach, R. (2004). Intersubject synchronization of cortical activity during natural vision. *Science*, *303*(5664), 1634-1640. https://doi.org/10.1126/science.1089506

Hegi, K. E., & Bergner, R. M. (2010). What is love? An empirically-based essentialist account. *Journal of Social and Personal Relationships*, *27*(5), 620-636. https://doi.org/10.1177/0265407510369605

Helm, J. L., Sbarra, D. A., & Ferrer, E. (2014). Coregulation of respiratory sinus arrhythmia in adult romantic partners. *Emotion*, *14*(3), 522. https://doi.org/doi.org/10.1037/a0035960

Hibbard, J. H., & Pope, C. R. (1993). The quality of social roles as predictors of morbidity and mortality. *Social science & medicine*, *36*(3), 217-225. https://doi.org/10.1016/0277-9536(93)90005-o

Hove, M. J., & Risen, J. L. (2009). It's all in the timing: Interpersonal synchrony increases affiliation. *Social cognition*, *27*(6), 949-960. https://doi.org/10.1521/soco.2009.27.6.949

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural equation modeling: a multidisciplinary journal*, *6*(1), 1-55. https://doi.org/10.1080/10705519909540118

Isen, A. M. (2000). Positive affect and decision making. In M. Lewis & J. Haviland-Jones (Eds.), *Handbook of emotions* (2nd ed ed., pp. 417-435). Guilford Press.

Jeličić, H., Phelps, E., & Lerner, R. M. (2009). Use of missing data methods in longitudinal studies: The persistence of bad practices in developmental psychology. *Developmental psychology*, *45*(4), 1195-1199. https://doi.org/10.1037/a0015665

Jones, S. M., & Wirtz, J. G. (2007). "Sad monkey see, monkey do:" Nonverbal matching in emotional support encounters. *Communication Studies*, *58*(1), 71-86. https://doi.org/10.1080/10510970601168731

Jöreskog, K. G. (1971). Simultaneous factor analysis in several populations. *Psychometrika*, *36*(4), 409-426. https://doi.org/10.1007/BF02291366

Kelley, H. H. (1992). Common-sense psychology and scientific psychology. *Annual Review of Psychology*, *43*(1), 1-24. https://doi.org/10.1146/annurev.ps.43.020192.000245

Kiecolt-Giaser, J., Malarkey, W. B., Chee, M., Newton, T., Cacioppo, J. T., Mao, H.-Y., & Glaser, R. (1993). Negative behavior during marital conflict is associated with immunological down-regulation. *Psychosomatic Medicine*, *55*, 395-409. https://doi.org/10.1097/00006842-199309000-00001

Kiecolt-Glaser, J. K., & Newton, T. L. (2001). Marriage and health: his and hers. *Psychological bulletin*, *127*(4), 472-503. https://doi.org/10.1037/0033-2909.127.4.472

King, L. A., Hicks, J. A., Krull, J. L., & Del Gaiso, A. K. (2006). Positive affect and the experience of meaning in life. *Journal of Personality and Social Psychology*, *90*(1), 179-196. https://doi.org/10.1037/0022-3514.90.1.179

Kok, B. E., Coffey, K. A., Cohn, M. A., Catalino, L. I., Vacharkulksemsuk, T., Algoe, S. B., Brantley, M., & Fredrickson, B. L. (2013). How positive emotions build physical health:

Perceived positive social connections account for the upward spiral between positive emotions and vagal tone. *Psychological science*, *24*(7), 1123-1132. https://doi.org/10.1177/0956797612470827

Kok, B. E., & Fredrickson, B. L. (2010). Upward spirals of the heart: Autonomic flexibility, as indexed by vagal tone, reciprocally and prospectively predicts positive emotions and social connectedness. *Biological psychology*, *85*(3), 432-436. https://doi.org/10.1016/j.biopsycho.2010.09.005

Kraut, R. E., & Johnston, R. E. (1979). Social and emotional messages of smiling: an ethological approach. *Journal of Personality and Social Psychology*, *37*(9), 1539-1553. https://doi.org/10.1037/0022-3514.37.9.1539

Kring, A. M., & Gordon, A. H. (1998). Sex differences in emotion: expression, experience, and physiology. *Journal of Personality and Social Psychology*, *74*(3), 686-703. https://doi.org/10.1037//0022-3514.74.3.686

Kroenke, K., & Spitzer, R. L. (1998). Gender differences in the reporting of physical and somatoform symptoms. *Psychosomatic Medicine*, *60*(2), 150-155. https://doi.org/10.1097/00006842-199803000-00006

Kurtz, L. E., & Algoe, S. B. (2015). Putting laughter in context: Shared laughter as behavioral indicator of relationship well-being. *Personal Relationships*, *22*(4), 573-590. https://doi.org/doi.org/10.1111/pere.12095

LaFrance, M., Hecht, M. A., & Paluck, E. L. (2003). The contingent smile: a meta-analysis of sex differences in smiling. *Psychological bulletin*, *129*(2), 305-334. https://doi.org/10.1037/0033-2909.129.2.305

Lai, J., Otero, M. C., Chen, K.-H., Wells, J. L., Levenson, R. W., & Fredrickson, B. L. (in prep). Positivity Resonance and its Associations with Synchronous Nonverbal Affiliative Behaviors and Perceived Lovingness in Long-Term Married Couples.

Laurenceau, J. P., Barrett, L. F., & Rovine, M. J. (2005). The interpersonal process model of intimacy in marriage: a daily-diary and multilevel modeling approach. *J Fam Psychol*, *19*(2), 314-323. https://doi.org/10.1037/0893-3200.19.2.314

Leon, A. C., Friedman, R. A., Sweeney, J. A., Brown, R. P., & Mann, J. J. (1990). Statistical issues in the identification of risk factors for suicidal behavior: the application of survival analysis. *Psychiatry research*, *31*(1), 99-108. https://doi.org/10.1016/0165-1781(90)90112-i

Levenson, R. W. (1994). Human emotion: A functional view. In P. Ekman & R. J. Davidson (Eds.), *The nature of emotion: Fundamental questions* (pp. 123-126). Oxford University Press.

Levenson, R. W. (2013). Emotion and emotion regulation. In D. Hermans, B. Rimé, & B. Mesquita (Eds.), *Changing Emotions* (pp. 105-112). Psychology Press.

Levenson, R. W. (2014). The autonomic nervous system and emotion. *Emotion review*, *6*(2), 100-112. https://doi.org/10.1177/1754073913512003

Levenson, R. W., Carstensen, L. L., & Gottman, J. M. (1993). Long-term marriage: Age, gender, and satisfaction. *Psychology and Aging*, *8*(2), 301-313. https://doi.org/10.1037/0882-7974.8.2.301

Levenson, R. W., Carstensen, L. L., & Gottman, J. M. (1994). Influence of age and gender on affect, physiology, and their interrelations: A study of long-term marriages. *Journal of*

Personality and Social Psychology, *67*(1), 56-68. https://doi.org/10.1037/0022-3514.67.1.56

Levenson, R. W., & Gottman, J. M. (1983). Marital interaction: physiological linkage and affective exchange. *J Pers Soc Psychol*, *45*(3), 587-597. https://doi.org/10.1037//0022-3514.45.3.587

Levenson, R. W., Haase, C. M., Bloch, L., Holley, S. R., & Seider, B. J. (2013). Emotion regulation in couples. In J. J. Gross (Ed.), *Handbook of emotion regulation* (2nd ed., pp. 267-283). Guilford Press.

Locke, H. J., & Wallace, K. M. (1959). Short marital-adjustment and prediction tests: Their reliability and validity. *Marriage and family living*, *21*(3), 251-255. https://doi.org/10.2307/348022

Lyubomirsky, S., King, L., & Diener, E. (2005). The benefits of frequent positive affect: Does happiness lead to success? *Psychological bulletin*, *131*(6), 803. https://doi.org/10.1037/0033-2909.131.6.803

Major, B. C., Le Nguyen, K. D., Lundberg, K. B., & Fredrickson, B. L. (2018). Well-Being Correlates of Perceived Positivity Resonance: Evidence From Trait and Episode-Level Assessments. *Pers Soc Psychol Bull*, *44*(12), 1631-1647. https://doi.org/10.1177/0146167218771324

Marci, C. D., Ham, J., Moran, E., & Orr, S. P. (2007). Physiologic correlates of perceived therapist empathy and social-emotional process during psychotherapy. *J Nerv Ment Dis*, *195*(2), 103-111. https://doi.org/10.1097/01.nmd.0000253731.71025.fc

Marci, C. D., & Orr, S. P. (2006). The effect of emotional distance on psychophysiologic concordance and perceived empathy between patient and interviewer. *Applied* *psychophysiology and biofeedback*, *31*(2), 115-128. https://doi.org/10.1007/s10484-006-9008-4

Mauss, I. B., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotion experience, behavior, and physiology. *Emotion*, *5*(2), 175-190. https://doi.org/10.1037/1528-3542.5.2.175

Mauss, I. B., Wilhelm, F., & Gross, J. (2004). Is there less to social anxiety than meets the eye? Emotion experience, expression, and bodily responding. *Cognition and Emotion*, *18*(5), 631-642. https://doi.org/10.1080/02699930341000112

McGinnis, J. M., Williams-Russo, P., & Knickman, J. R. (2002). The case for more active policy attention to health promotion. *Health affairs*, *21*(2), 78-93. https://doi.org/10.1377/hlthaff.21.2.78

McGonagle, K. A., Kessler, R. C., & Schilling, E. A. (1992). The frequency and determinants of marital disagreements in a community sample. *Journal of Social and Personal Relationships*, *9*(4), 507-524. https://doi.org/10.1177/0265407592094003

Meltzoff, A. N., & Moore, M. K. (1989). Imitation in Newborn Infants: Exploring the Range of Gestures Imitated and the Underlying Mechanisms. *Developmental psychology*, *25*(6), 954-962. https://doi.org/10.1037/0012-1649.25.6.954

Miller, G. E., Dopp, J. M., Myers, H. F., Stevens, S. Y., & Fahey, J. L. (1999). Psychosocial predictors of natural killer cell mobilization during marital conflict. *Health Psychology*, *18*(3), 262-271. https://doi.org/10.1037//0278-6133.18.3.262

Niedenthal, P. M., Mermillod, M., Maringer, M., & Hess, U. (2010). The Simulation of Smiles (SIMS) model: Embodied simulation and the meaning of facial expression. *Behavioral and brain sciences*, *33*(6), 417-433. https://doi.org/10.1017/S0140525X10000865

Olsen, J. A., & Kenny, D. A. (2006). Structural equation modeling with interchangeable dyads. *Psychological methods*, *11*(2), 127-141. https://doi.org/10.1037/1082-989X.11.2.127

Otero, M. C., Wells, J. L., Chen, K. H., Brown, C. L., Connelly, D. E., Levenson, R. W., & Fredrickson, B. L. (2019). Behavioral indices of positivity resonance associated with long-term marital satisfaction. *Emotion*, *20*(7), 1225-1233. https://doi.org/10.1037/emo0000634

Phillipson, C. (1997). Social relationships in later life: a review of the research literature. *International Journal of Geriatric Psychiatry*, *12*(5), 505-512. https://doi.org/10.1002/(sici)1099-1166(199705)12:5<505::aid-gps577>3.0.co;2-q

Pietromonaco, P. R., & Collins, N. L. (2017). Interpersonal mechanisms linking close relationships to health. *American Psychologist*, *72*(6), 531-542. https://doi.org/10.1037/amp0000129

Pinquart, M. (2001). Correlates of subjective health in older adults: a meta-analysis. *Psychology and Aging*, *16*(3), 414-426. https://doi.org/10.1037//0882-7974.16.3.414

Pressman, S. D., & Cohen, S. (2005). Does positive affect influence health? *Psychological bulletin*, *131*(6), 925-971. https://doi.org/10.1037/0033-2909.131.6.925

Prinzing, M. M., Zhou, J., West, T. N., Le Nguyen, K. D., Wells, J. L., & Fredrickson, B. L. (2020). Staying 'in sync' with others during COVID-19: Perceived positivity resonance mediates cross-sectional and longitudinal links between trait resilience and mental health. *The Journal of Positive Psychology*, 1-16. https://doi.org/10.1080/17439760.2020.1858336

Reis, H. T. (2014). Responsiveness: Affective interdependence in close relationships. In M. Mikulincer & P. Shaver (Eds.), *Mechanisms of social connection: From brain to group* (pp. 255-271). American Psychological Association. https://doi.org//10.1037/14250-015

Reis, H. T., Clark, M. S., & Holmes, J. G. (2004). Perceived partner responsiveness as an organizing construct in the study of intimacy and closeness. In D. J. Mashekk & A. P. Aron (Eds.), *Handbook of closeness and intimacy* (pp. 201-225). Lawrence Erlbaum Associates Publishers.

Richman, L. S., Kubzansky, L., Maselko, J., Kawachi, I., Choo, P., & Bauer, M. (2005). Positive emotion and health: Going beyond the negative. *Health Psychology*, *24*(4), 422-429. https://doi.org/10.1037/0278-6133.24.4.422

Robles, T. F., & Kiecolt-Glaser, J. K. (2003). The physiology of marriage: pathways to health. *Physiology & behavior*, *79*(3), 409-416. https://doi.org/10.1016/s0031-9384(03)00160-4

Rook, K. S., & Charles, S. T. (2017). Close social ties and health in later life: Strengths and vulnerabilities. *American Psychologist*, *72*(6), 567-577. https://doi.org/10.1037/amp0000104

Rosenberg, E. L., & Ekman, P. (1994). Coherence between expressive and experiential systems in emotion. *Cognition & Emotion*, *8*(3), 201-229. https://doi.org/10.1080/02699939408408938

Rosseel, Y. (2012). lavaan: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, *48*(2), 1-36. http://www.jstatsoft.org/v48/i02/

Schoenfeld, D. (1982). Partial Residuals for The Proportional Hazards Regression Model. *Biometrika*, *69*(1), 239-241. https://doi.org/10.2307/2335876

Selcuk, E., & Ong, A. D. (2013). Perceived partner responsiveness moderates the association between received emotional support and all-cause mortality. *Health Psychology*, *32*(2), 231-235. https://doi.org/10.1037/a0028276

Shelton, C. A., Umapathy, C., Stello, K., Yadav, D., & Whitcomb, D. C. (2018). Hereditary pancreatitis in the United States: survival and rates of pancreatic cancer. *The American journal of gastroenterology*, *113*(9), 1376. https://doi.org/10.1038/s41395-018-0194-5

Sin, N. L., & Lyubomirsky, S. (2009). Enhancing well-being and alleviating depressive symptoms with positive psychology interventions: a practice-friendly meta-analysis. *Journal of Clinical Psychology*, *65*(5), 467-487. https://doi.org/10.1002/jclp.20593

Smith, T. W., Baron, C. E., & Grove, J. L. (2014). Personality, emotional adjustment, and cardiovascular risk: Marriage as a mechanism. *Journal of Personality*, *82*(6), 502-514. https://doi.org/doi.org/10.1111/jopy.12074

Smith, T. W., & Gallo, L. C. (1999). Hostility and cardiovascular reactivity during marital interaction. *Psychosomatic Medicine*, *61*(4), 436-445. https://doi.org/10.1097/00006842-199907000-00005

Smith, T. W., Glazer, K., Ruiz, J. M., & Gallo, L. C. (2004). Hostility, anger, aggressiveness, and coronary heart disease: An interpersonal perspective on personality, emotion, and health. *Journal of Personality*, *72*(6), 1217-1270. https://doi.org/10.1111/j.1467-6494.2004.00296.x

Stanton, S. C., Selcuk, E., Farrell, A. K., Slatcher, R. B., & Ong, A. D. (2019). Perceived partner responsiveness, daily negative affect reactivity, and all-cause mortality: A 20-year longitudinal study. *Psychosomatic Medicine*, *81*(1), 7. https://doi.org/10.1097/PSY.0000000000000618

Stavrova, O. (2019). Having a happy spouse is associated with lowered risk of mortality. *Psychological science*, *30*(5), 798-803. https://doi.org/10.1177/0956797619835147

Stephens, G. J., Silbert, L. J., & Hasson, U. (2010). Speaker-listener neural coupling underlies successful communication. *Proceedings of the National Academy of Sciences*, *107*(32), 14425-14430. https://doi.org/10.1073/pnas.1008662107

Stern, D. N., Hofer, L., Haft, W., & Dore, J. (1985). Affect attunement: The sharing of feeling states between mother and infant by means of inter-modal fluency. In T. M. Field & N. A. Fox (Eds.), *Social perception in infants* (pp. 249-268). Abbex.

Thayer, J. F., & Sternberg, E. (2006). Beyond heart rate variability: vagal regulation of allostatic systems. *Annals of the New York Academy of Sciences*, *1088*(1), 361-372. https://doi.org/10.1196/annals.1366.014

Therneau, T. M. (2020). *A Package for Survival Analysis in R*. https://CRAN.R-project.org/package=survival

Therneau, T. M., & Grambsch, P. M. (2000). The Cox Model. In *Modeling Survival Data: Extending the Cox Model. Statistics for Biology and Health.* (pp. 39-77). Springer. https://doi.org/10.1007/978-1-4757-3294-8_3

Thibaut, J. W., & Kelley, H. H. (1959). *The social psychology of groups*. Routledge. https://doi.org/10.4324/9781315135007

Tickle-Degnen, L., & Rosenthal, R. (1990). The nature of rapport and its nonverbal correlates. *Psychological Inquiry*, *1*(4), 285-293. https://doi.org/10.1207/s15327965pli0104_1

Timmons, A. C., Margolin, G., & Saxbe, D. E. (2015). Physiological linkage in couples and its implications for individual and interpersonal functioning: A literature review. *Journal of family psychology*, *29*(5), 720-731. https://doi.org/10.1037/fam0000115

Tugade, M. M., & Fredrickson, B. L. (2004). Resilient individuals use positive emotions to bounce back from negative emotional experiences. *Journal of Personality and Social Psychology*, *86*(2), 320-333. https://doi.org/10.1037/0022-3514.86.2.320

Tukey, J. W. (1962). The future of data analysis. *The annals of mathematical statistics*, *33*(1), 1-67. https://doi.org/10.1214/aoms/1177704711

Turner, R. J., & Marino, F. (1994). Social support and social structure: A descriptive epidemiology. *Journal of Health and Social Behavior*, *35*(3), 193-212. https://doi.org/10.2307/2137276

U.S. Bureau of the Census. (2011). *Number, Timing, and Duration of Marriages and Divorces: 2009*. https://www.census.gov/prod/2011pubs/p70-125.pdf

Umberson, D. (1992). Relationships between adult children and their parents: Psychological consequences for both generations. *Journal of Marriage and the Family*, *54*(3), 664-674. https://doi.org/10.2307/353252

Vacharkulksemsuk, T., & Fredrickson, B. L. (2012). Strangers in sync: Achieving embodied rapport through shared movements. *Journal of experimental social psychology*, *48*(1), 399-402. https://doi.org/10.1016/j.jesp.2011.07.015

Valdesolo, P., & Desteno, D. (2011). Synchrony and the social tuning of compassion. *Emotion*, *11*(2), 262-266. https://doi.org/10.1037/a0021302

van Kimmenade, R. R., Mohammed, A. A., Uthamalingam, S., van der Meer, P., Felker, G. M., & Januzzi Jr, J. L. (2010). Red blood cell distribution width and 1-year mortality in acute heart failure. *European journal of heart failure*, *12*(2), 129-136. https://doi.org/10.1093/eurjhf/hfp179

Weaver, C. A., Ko, Y. H., Alexander, E. R., Pao, Y. L., & Ting, N. (1980). The Cornell Medical Index as a predictor of health in a prospective cardiovascular study in Taiwan. *American Journal of Epidemiology*, *111*(1), 113-124. https://doi.org/10.1093/oxfordjournals.aje.a112861

West, T. N., Le Nguyen, K. D., Zhou, J., Prinzing, M. M., Wells, J. L., & Fredrickson, B. L. (2021). How the Affective Quality of Day-to-Day Social Connections May Contribute to Public Health: Prosocial Tendencies Account for the Links Between Positivity Resonance and Behaviors that Reduce the Spread of COVID-19. *Affective Science*, *2*, 241-261. https://doi.org/10.1007/s42761-021-00035-z

Whisman, M. A., Gilmour, A. L., & Salinger, J. M. (2018). Marital satisfaction and mortality in the United States adult population. *Health Psychology*, *37*(11), 1041. https://doi.org/10.1037/hea0000677

Wu, D. J., Svoboda, R. C., Bae, K. K., & Haase, C. M. (2021). Individual differences in sadness coherence: Associations with dispositional affect and age. *Emotion*, *21*(3), 465-477. https://doi.org/10.1037/emo0000731

Yuan, J. W., McCarthy, M., Holley, S. R., & Levenson, R. W. (2010). Physiological down-regulation and positive emotion in marital interaction. *Emotion*, *10*(4), 467. https://doi.org/10.1037/a0018699

Zhou, J., Prinzing, M. M., Le Nguyen, K. D., West, T. N., & Fredrickson, B. L. (in press). The goods in everyday love: Positivity resonance builds prosociality. *Emotion*.