Staying 'In Sync' with Others During COVID-19:

Perceived Positivity Resonance Mediates Cross-Sectional and Longitudinal Links between Trait Resilience and Mental Health

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Abstract

Shared positive emotions involving caring and synchrony—termed "positivity resonance"—are associated with mental health (Major et al., 2018). We hypothesized that, during the COVID-19 pandemic, individual differences in trait resilience would be linked with better overall mental health in part because those higher in trait resilience experience more positivity resonance. We surveyed respondents nationally in April and May of 2020 (total *N* = 1,059), during pervasive stay-at-home orders. Participants completed self-reports of trait resilience and mental health and used the Day Reconstruction Method to describe their social and emotional experiences. Structural equation models showed perceived positivity resonance to mediate the links between trait resilience and mental health outcomes. Subsequent analyses showed these mediating effects to be independent of overall positive emotion and social interaction quantity (amongst nationwide adults). These results indicate that high-quality social connection played a uniquely important role in maintaining mental health during the COVID-19 pandemic.

Keywords: positive psychology; affective science; broaden-and-build theory; well-being; social interaction

Wordcount: 8,027

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As the disease caused by SARS-CoV-2 (COVID-19) spread across the world, many local authorities imposed "lockdowns" or "stay at home" orders, which restricted citizens' ability to leave their homes and socialize. Such measures are known to be effective for protecting public health by slowing viral spread and "flattening the curve" (Greenstone & Nigam, 2020; Jefferson et al., 2008). However, given the critical role social interaction plays in sustaining individuals' health and happiness (Holt-Lunstad et al., 2010; Major et al., 2018; Nelson et al., 2016), such measures can also be expected to come with costs to individual well-being. Sources of poor mental health in the United States (US) during the early stages of the pandemic were many: fear of contracting the virus, concern for others dealing with it, worries about economic consequences (e.g., unemployment), and so on. The National Center for Health Statistics reported that, between April and June of 2020, roughly a third of individuals living in the US showed signs of clinical levels of anxiety or depression (NCHS, 2020). Poor mental health is bad for its own sake. Yet it's also a risk factor for *physical* ill-health, shown to precede and predict increased all-cause mortality, cardiovascular disease, and poor overall physical health (R. Cohen et al., 2016; Roepke et al., 2014). In particular, psychological stress and low levels of felt social integration are known to increase susceptibility to respiratory illnesses (S. Cohen, 2020)—a category that includes COVID-19.

Psychological Resilience and Positive Emotion

Psychological resilience refers to an individual's ability to flexibly adapt to ever-changing circumstances, cope effectively with adversity, and spring back quickly from setbacks (Block & Kremen, 1996; Jacelon, 1997). At a physiological level, those who score higher (vs. lower) on self-report measures of this trait show faster cardiovascular recovery from negative emotional arousal (Lü et al., 2016; Souza et al., 2007, 2013; Tugade & Fredrickson, 2004). At a neurological level, these individuals tend to show faster recovery in brain areas that index negative affectivity (Waugh et al., 2008). And, at the psychological level, self-reported trait resilience has been linked with better overall mental health (Hu et al., 2015)—i.e., more of the positive aspects (e.g., pleasant emotion and life satisfaction) and less of the negative aspects (e.g., depression and anxiety).[1]

Past research has found that resilient individuals maintain their better overall mental health, even during crises, partly through experiencing positive emotion more frequently than less resilient people. For instance, one study (Fredrickson et al., 2003) that examined negative mental health symptoms in the aftermath of the terrorist attacks on September 11, 2001 in the US found that individuals who scored higher on self-report measures of resilience prior to the attacks showed fewer depressive symptoms in the weeks following the attacks, and that this link was fully mediated by reported positive emotions. Because positive emotions can "undo" the lingering aftereffects of negative

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[1] The distinction between the positive and negative aspects of mental health is an important one. The absence of negative aspects of mental health does not entail the presence of positive aspects. The positive and negative aspects have been shown to be separate constructs (Keyes, 2007; Payton, 2009), and to display different associations with psychological processes and outcomes (Catalino & Fredrickson, 2011).

emotions (Fredrickson et al., 2001), they have been shown to help individuals bounce back from stressful experiences (Tugade & Fredrickson, 2004). Subsequent studies, employing both self-report and brain imaging methodologies, have found that individuals who score higher (vs. lower) on trait resilience more flexibly adapt their emotional states in response to changing environmental circumstances (Ong et al., 2016; Waugh et al., 2008, 2011). This may explain how these individuals are able, even under difficult conditions, to cultivate greater positive emotions, avoid ruminating on negative emotions, and thereby maintain better overall mental health.

According to the Broaden-and-Build Theory of positive emotions (Fredrickson, 1998, 2013b), frequent experiences of positive emotions help people to build durable personal resources, such as optimism and social support (Fredrickson et al., 2008). Positive emotions have also been found to facilitate the development of trait resilience itself (Cohn et al., 2009; Tugade & Fredrickson, 2007). This suggests that the relationship between trait resilience and positive emotions shows the reciprocal causality indicative of an upward spiral: Trait resilience enables people to experience more positive emotions, which in turn can facilitate greater resilience.

Positivity Resonance Theory

The Positivity Resonance Theory is an offshoot of the Broaden-and-Build Theory that centers on the special case of co-experienced positive affect.[2] The theory holds that pleasant states that are co-experienced with other people and marked by caring and

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[2] We use the term “affect” and not “emotion” when describing Positivity Resonance Theory to acknowledge that affective valence may be shared even when specific positive emotions (e.g., gratitude, love, pride) are not shared.

synchrony are especially strong contributors to mental health and growth in personal and social resources (Fredrickson, 2013a, 2016). These high-quality emotional connections are termed “positivity resonance.” Just as emotions are defined in terms of coordinated responses across experiential, behavioral, and physiological systems (Levenson, 2014; Mauss et al., 2005), positivity resonance is defined as occurring within social interactions that are characterized by coordinated increases in three key features: shared positive affect (an experiential component), caring nonverbal synchrony (a behavioral component), and biological synchrony (a physiological component).[3]

The experiential component, shared positive affect, is a pleasant subjective state, co-experienced by multiple individuals. The behavioral component, caring nonverbal synchrony, encompasses the coordinated movements and gestures (facial and bodily) that indicate each person’s concern for the well-being of the other(s). This can include mutual direct body orientation and gaze, smiles, nods, and forward leans (Gonzaga et al., 2001; Tickle-Degnen & Rosenthal, 1990), as well as a nonconscious coordination of body movements in form, tempo, and intensity (Bernieri et al., 1988; Vacharkulksemsuk & Fredrickson, 2012). Such behaviors communicate to interaction partners engagement, support, and responsivity (Sharon-David et al., 2019), and ultimately, attentive care and goodwill (Reis et al., 2004). The physiological component, biological synchrony, occurs

[3] This way of presenting the three key features of positivity resonance differs slightly from earlier presentations (Fredrickson, 2013a, 2016). Previously, these were described as: “(1) shared positive emotion, (2) mutual care, and (3) biobehavioral synchrony” (Fredrickson, 2016, p. 852). However, by distinguishing behavioral from biological synchrony, this updated articulation better aligns with widely endorsed theories of emotion that operationalize emotions in terms of coherence among experiential, behavioral, physiological responses.

in moments when the biological processes of two or more people show parallel changes. Such biological linkage has been found to occur during positive social interactions (Feldman, 2015; Marci et al., 2007; Stephens et al., 2010).

Positivity Resonance is a Uniquely Powerful Contributor to Mental Health

The Positivity Resonance Theory posits that benefits associated with positive affect become amplified when it is shared. The theory thus predicts that positivity resonance is a particularly powerful contributor to mental health outcomes, beyond the benefits associated with positive affect in general, or social interaction in general.

Past research suggests that experiences of positivity are greater in social contexts. Studies have found that shared laughter is experienced as more pleasant than unshared laughter (Kurtz & Algoe, 2017), and that fun activities (e.g., game playing) come with more positive emotions when they are social rather than solitary (Reis et al., 2017). Even eating chocolate is experienced as more pleasant when done with others (Boothby et al., 2014). Moreover, sharing good news (Gable et al., 2004), and expressing appreciation (Algoe et al., 2013) have been found to amplify positive emotions.

Evidence also suggests that shared positive affect fortifies close relationships. In our own work, we have found that the frequency of co-experienced positive affect during conversation is uniquely linked with relationship quality in long-term married couples, independent of the frequency of individually-experienced positive affect and co-experienced negative affect (C. L. Brown et al., in press).

We’ve also found that synchronized body movements (the behavioral component of positivity resonance) during conversations between new acquaintances predict later reports of embodied rapport, and do so independently from reports of experienced positive emotions (Vacharkulksemsuk & Fredrickson, 2012). This correlational evidence is consistent with the results of randomized experiments that show causal links between nonverbal synchrony and compassion (Valdesolo & DeSteno, 2011), perceived emotional support (Jones & Wirtz, 2007), and affiliation (Hove & Risen, 2009).

Synchrony in autonomic physiology (also called “physiological linkage”) has also been related to higher-quality relationships (Helm et al., 2014) and social bonding (for a review, see Feldman, 2015). In our own research, we have found that shared positive affect in long-term married couples (whether indexed by behavioral or experiential responses) is associated with synchrony between spouses’ heart rates, sweat gland activity, and peripheral vasoconstriction. In addition, we found that shared positive affect is more strongly associated with this physiological linkage than is shared negative affect, shared neutral states, or unshared affect. Moreover, physiological linkage during shared positive affect was consistently associated with higher-quality interactions and relationships, both concurrently and longitudinally (Chen et al., 2020).

Because positivity resonance is defined as a dyadic or group-level phenomenon, optimal measures of this collective affective experience incorporate self-reports from multiple interactants (C. L. Brown et al., in press), or better yet behavioral indicators (Otero et al., 2019), and/or indicators of physiological linkage (Chen et al., 2020). Yet practical hurdles to collecting such data abound—especially during a global pandemic. Fortunately, individual self-reports of *perceived* positivity resonance have been found to be distinct from individual self-reports of positive affect.

In a series of three studies (total N = 468) Major and colleagues (2018) showed that self-reports of perceived positivity resonance, consistent with theory, were associated with greater positive mental health (*rs* between .36 and .44) and reduced negative mental health (*rs* between –.29 and –.38). Moreover, these links remained significant even when controlling for people's more general pleasant emotions, or the frequency or duration of their daily social interactions. Two of these three studies assessed perceived positivity resonance at the level of social episodes, using the Day Reconstruction Method (DRM; Kahneman et al., 2004). In a DRM survey, respondents are first asked to recall and relive all the specific episodes of their previous day, and then to report on their experiences within each episode. Although technically a retrospective self-report, the DRM has been well-established to minimize retrospection biases (Kahneman & Krueger, 2006). Additionally, when reports of perceived positivity resonance are aggregated across all of a respondent's social episodes within a targeted day, the computed person-level index of perceived positivity resonance becomes more reliable. The rich episode-level data provided by the DRM also enable researchers to disentangle perceived positivity resonance from closely related features of daily life, such as social interaction and more general pleasant emotions.

Positivity resonance may be harder to come by when people are mandated (or strongly encouraged) to stay at home to prevent viral spread during a pandemic. Yet, both the Broaden-and-Build Theory (Fredrickson, 1998, 2013b) and the Positivity Resonance Theory (Fredrickson, 2016) suggest that people who manage to create more of these moments of high-quality connection within remaining social interactions should show better mental health. Moreover, resilient individuals, who, as indicated, flexibly adapt to ever-changing circumstances, may be better able to create these moments. Therefore, we sought to test the following hypotheses: During the COVID-19 pandemic, perceived positivity resonance, assessed at the level of social episodes via the DRM, mediates the links between individual differences in trait resilience and markers of both positive and negative mental health—both cross-sectionally (H1), and longitudinally, over two months (H2).

Moreover, we predicted that this hypothesized mediation would be robust to subsequent sensitivity analyses that include closely related variables like overall positive emotion and quantity of social interaction. Positive emotion and quantity of interaction make for particularly apt comparison variables, as they are both well-established contributors to mental health (Fredrickson, 2013b; Pachucki et al., 2015) and, by definition, positive emotion and social interaction are each necessary, though not sufficient, conditions for the emergence of positivity resonance. Hence, it is important to rule out the possibility that positivity resonance is only conducive to mental health insofar as it encompasses these other, closely related variables. For this reason, we planned to add these constructs to our models as parallel mediators. If perceived positivity resonance facilitates mental health independently of positive emotion and social interaction, then this would provide evidence for the importance of this unique amalgam construct for understanding mental health.

Method

Participants

We collected two samples. The first sample was recruited from across the US using Amazon's Mechanical Turk. A subset of these participants returned for follow-up assessments, one and two months later. The second sample was composed of undergraduate students from two large, public universities, one in California and one in North Carolina. (These participants did not return for follow-up.)

Sample 1: Nationwide adults. Sample 1 participants were initially recruited through Amazon's Mechanical Turk between April 1st and 8th, 2020 (T1). They received $3 (USD) in exchange for their participation. Participants were eligible if they were over 18, fluent in English, and residing in the US. We received 725 responses. The survey included several attention checks: questions reading "This is an attention check. Please mark 'Strongly disagree.'" Those who did not give the requested response on more than one of these attention checks (n = 27) were excluded from analysis. Some participants (n = 123) were also excluded for problems that suggested they did not follow instructions for the DRM: nonsensical text entries, no entries at all, or impossible or nonsensical time ranges. This left N = 575 participants in our T1 analysis sample (M_{age} = 36.69, SD_{age} = 11.54; 50% male, 8% Asian, 14% Black or African American, 4% Hispanic or Latinx, 65% White or European American, 7% Other, mixed, or preferred not to say). Most of Sample 1 resided across the US. However, to enable possible comparisons with Sample 2, we oversampled Californians (n = 167) and North Carolinians (n = 151).[4]

Approximately one month later (T2: April 29th – May 7th, 2020), the 575 participants included in the T1 analysis sample were invited to complete a shorter, follow-up survey in exchange for $1 (USD). We received 330 responses. Of these, some (n = 3) failed more than one attention check and were excluded from analysis. Others (n = 27) were

[4] We do not make use of this feature of Sample 1 because analyses that used region of the US (i.e., CA, NC, other) as a statistical covariate did not affect the results reported here. See Sensitivity Analyses for details.

excluded for problems with their DRM responses: nonsensical text entries, no entries at all, or impossible or nonsensical time ranges. This left *N* = 300 participants in our T2 analysis sample (*n* = 91 Californians, *n* = 85 North Carolinians; M_{age} = 39.16, SD_{age} = 12.01; 9% Asian, 11% Black or African American, 4% Hispanic or Latinx, 68% White or European American, 7% Other, mixed, or preferred not to say).

Approximately another month later (T3: between May 27^{th} and June 4^{th}), 252 participants completed the same follow-up survey a second time, again for $1 (USD). Of these 1 failed more than one attention check, leaving N = 251 participants in our T3 analysis sample (*n* = 70 Californians, *n* = 74 North Carolinians; M_{age} = 39.22, SD_{age} = 11.66; 8.8% Asian, 12.8% Black or African American, 3.6% Hispanic or Latinx, 67.6% White or European American, 6.4% Other, mixed, or preferred not to say).

Sample 2: Undergraduate students. Sample 2 participants were recruited through Introductory Psychology participant pools between March 28th and April 30th, 2020. They received course credit for participating. Students were eligible if they were over 18 and currently residing in the US. We received 595 responses (*n* = 421 from the university in California, *n* = 174 from the university in North Carolina). The survey included several attention checks: questions reading “This is an attention check. Please mark ‘Strongly disagree’.” Those who did not give the requested response on more than one of these attention checks (*n* = 34), were excluded from analysis. Others (*n* = 67) were excluded for problems with their DRM responses: nonsensical text entries, no entries at all, or impossible or nonsensical time ranges. Finally, because of our focus on the pandemic within the US, we also excluded students who were currently residing outside the US (*n* = 10). This left *N* = 484 participants in the analysis sample (*n* = 334 from the university in California, n = 140 from the university in North Carolina; M_{age} = 20.45, SD_{age} = 2.89; 31.2% male; 36% Asian, 3% Black or African American, 11% Hispanic or Latinx, 34% White or European American, 16% Other, mixed, or prefer not to say).

Procedure

Participants first completed the DRM survey (Kahneman et al., 2004). This method asks participants to break down their previous day into a series of episodes, and then report on what happened and how they felt during those episodes. Previous research has found that the DRM can provide data of comparable quality to experience sampling methods without interrupting the very experiences being measured (Grube et al., 2008; Kahneman et al., 2004; Stone et al., 2006). Our participants were asked to list all episodes from the time they woke up until they went to bed on the previous day, giving each episode a brief name and start and end times. They could also write private notes to help recall what they were doing and how they felt. We aggregated these episode-level reports to create person-level scores of perceived positivity resonance, positive emotions, and frequency of social interaction. Trait resilience, as well as positive and negative mental health were then assessed using separate survey measures.

Measures

Positive Emotion. For each episode in the DRM, participants indicated the extent to which they experienced positive and negative emotions, respectively, during that episode. They were presented with the following instructions: “Now think about how you felt during this episode. Think about whether or not you felt any pleasant or unpleasant emotions. Pleasant emotions include: amusement, awe, joy, gratitude, hope, inspiration, interest, love, pride, compassion, contentment. Unpleasant emotions include: anxiety, anger, shame, fear, hate, disgust, embarrassment, guilt, sadness, stress. Please indicate the greatest amount that you experienced [pleasant/unpleasant] emotions during this episode." Participants responded using 5-point Likert scales (1 = not at all, 5 = extremely). Overall positive emotion scores were calculated by averaging the positive emotion scores across all episodes for each participant. (Negative emotion scores were not used in this study).

Social Interaction Quantity. For each episode, participants were also asked if they were interacting with anyone (including via phone calls, texting, email, and social media) for more than a few minutes during that episode. We used the number of episodes during which participants reported that they were interacting as a measure of social interaction quantity.

Perceived Positivity Resonance. If social interaction was reported for a given episode, we also assessed perceived positivity resonance using an abbreviated version of the Perceived Positivity Resonance Scale (Major et al., 2018). To reduce participant burden, we chose two items that clearly reflected the key features of positivity resonance (i.e., shared positive affect, mutual care, synchrony), and that were highly correlated with the full scale (r = .97) in a previous study (Zhou et al., under review). Specifically, participants were asked to indicate the proportion of time during their social interaction (from 0% to 100%) that they "...experienced a mutual sense of warmth and concern toward one another" and "...felt 'in sync' with the other(s)". Responses to these items were averaged to create a perceived positivity resonance score for that episode. The standardized coefficient α (for use with two-item scales; Eisinga et al., 2013) was .87 for

Sample 1 and .89 for Sample 2. Person-level perceived positivity resonance scores for each participant were calculated as the mean score across all reported social episodes.

Trait Resilience. We assessed individual differences in trait resilience using the Ego Resiliency Scale Short Form (ER89; Alessandri et al., 2012), a 10-item version of the original ER89 (Block & Kremen, 1996), which our team's past work has validated against biological measures (Tugade & Fredrickson, 2004; Waugh et al., 2008). This questionnaire asks participants to use a 7-point Likert scale (1 = does not apply at all, 7 = applies very strongly) to indicate the degree to which a series of statements apply to them (sample item: "I quickly get over and recover from being startled"). This scale showed adequate internal reliability in both samples (coefficient αs = .78, and .73, in Samples 1 and 2, respectively).

Positive Mental Health (PMH). We used two measures to assess positive mental health. The first was the Mental Health Continuum – Short Form (MHC-SF), which includes 3 items intended to assess "hedonic" components of well-being and 11 intended to assess "eudaimonic" components (Keyes, 2009). The scale asks participants to indicate on a 6-point Likert scale (1 = never, 6 = every day) how often in the past month they have experienced various aspects of positive psychosocial health (sample items: "satisfied with life", "that you had something important to contribute to society"). This scale showed excellent internal reliability in both samples (coefficient αs = .93 and .92, respectively). The second measure was a modified version of the Multidimensional Existential Meaning Scale (mMEMS; original MEMS: George & Park, 2017), which was designed to assess participants' perceptions that their lives are meaningful—a central aspect of eudaimonic well-being (Martela & Sheldon, 2019; Vitterso, 2016). Perceived meaning in life has been theorized to consist of three subconstructs (George & Park, 2016; Martela & Steger, 2016): comprehension (the perception that one's life makes sense), purpose (the perception that one's life has some direction or goal), and mattering (the perception that one's life is significant or worthwhile). The MEMS, therefore, has a 5-item subscale for each subconstruct. However, the mattering subscale from the original version of the MEMS (George & Park, 2017) includes references to "the grand scheme of the universe", which we have found to distort participants' responses (Prinzing & Fredrickson, in prep). Hence, in this study, we replaced the original MEMS mattering subscale with 5 parallel items of our own that do not situate mattering in cosmic or other terms (i.e., "My life matters"; "My life is important"; "The things I do are important"; "My life is worthwhile"; "The things I do have value and significance"). The full mMEMS showed excellent internal reliability in both samples (coefficient αs = .96 and .96, respectively).

Negative Mental Health (NMH). We assessed negative mental health using the anxiety, depression, loneliness, and stress scales from the Patient-Reported Outcomes Measurement Information System (PROMIS; Hays et al., 2018). These are 4-item questionnaires (apart from loneliness which has 5 items) that were developed using item response theory (Hambleton & Swaminathan, 2013). They ask participants to use a 5-point Likert scale (1 = never, 6 = always) to report how often in the past week they have experienced various aspects of negative psychosocial health (sample items: from the anxiety scale, "My worries overwhelmed me"; from the depression scale, "I felt worthless"; from the loneliness scale, "I felt alone"; from the stress scale, "I felt nervous or 'stressed'"). These scales all showed excellent internal reliability in both samples (all coefficient αs > .89).

Analytic Plan

We first used the *lavaan* package (Rosseel, 2012) in R 4.0.0 to evaluate our working assumption that the manifest mental health variables would yield two latent variables, that separately reflect positive and negative mental health. Specifically, we conducted a multi-group Confirmatory Factor Analysis (MGCFA; T. A. Brown, 2015; Widaman & Reise, 1997) to test a two-factor measurement model, and then evaluated whether the factor loadings and item intercepts could be constrained to equality across samples (a test of strong measurement invariance).

Following assessment of measurement invariance, and using the same *lavaan* package in R 4.0.0, we next fit multi-group structural equation models to test whether perceived positivity resonance mediates the links between trait resilience and mental health (both positive and negative), with separate cross-sectional (H1) and longitudinal (H2) models. Due to discrepancy in numerical range between perceived positivity resonance scores (0-100) and other variables (1-7), we divided perceived positivity resonance scores by 10 before adding to all models.

Finally, we conducted sensitivity analyses to evaluate whether the hypothesized mediation effect of perceived positivity resonance would remain independently of: (1) alternative mediators that are conceptually close to positivity resonance—namely, overall positive emotion and quantity of social interaction; (2) demographic covariates including gender, age, ethnicity and geographic region. Due to random, partial missing data, and non-normal distributions for certain variables, we used a full information maximum likelihood (FIML) estimator with robust standard errors for all models. The chi-square goodness of fit test, Standardized Root Mean Square Residual (SRMR), robust

Confirmatory Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA) are reported for the primary models to indicate model fit.

Results

Descriptive Statistics

In the DRM survey, participants averaged around 10 total episodes ($M_{Sample1}$ = 10.86, $SD_{Sample1}$ = 5.73, range 1-30; $M_{Sample2}$ = 10.13, $SD_{Sample2}$ = 5.06, range 1-30;), about 5 of which included social interaction ($M_{Sample1}$ = 4.99, $SD_{Sample1}$ = 3.42, range 1-30; $M_{Sample2}$ = 5.42, $SD_{Sample2}$ = 2.72, range 1-20). Sample sizes and zero-order correlations for and among all study variables are presented in Table 1. Means, standard deviations and *t*-tests comparing cross-sample differences are presented in Table 2. We used the recommended cut-off scores for the PROMIS measures (Health Measures, 2020; Morgan et al., 2017) to assess the degree of negative mental health in each sample at T1. We found that large proportions of both samples reported moderate to severe levels of anxiety (Sample 1: 39.3%; Sample 2: 45.5%), depression (Sample 1: 30.3%; Sample 2: 31.2%), loneliness (Sample 1: 32.3%; Sample 2: 35.5%), and stress (Sample 1: 37.9%; Sample 2: 57.6%). These patterns corroborate recent findings from nationally representative samples, indicating a significant increase in such symptoms from the same time the previous year (i.e., 2019; NCHS, 2020).

[*Table 1*. Correlation Tables of Variables of Interest Grouped by Samples.]

Testing Measurement Models Within and Across Samples

[Table 2. Descriptive Statistics and Sample Comparison]

We first conducted an MGCFA (T. A. Brown, 2015; Widaman & Reise, 1997) in the two student samples (i.e., from the universities in California and North Carolina) to test our assumption that the factor structure for each group would reflect two latent variables of positive and negative mental health. We fit a minimally identified model (configural model), in which the loadings and intercepts of the first indicators for each factor (mental health continuum for PMH and depression for NMH) were constrained to equality across samples, with both factor means and variances standardized for the Californian university sample as references. All factor loadings were allowed to differ across samples. The results from this model suggested that all factor loadings were significantly different from zero (ps < .001). Using the measurement invariance test in the *semTools* package (Jorgensen et al., 2016), we then tested measurement invariance of the factor structure across two student samples. The test of measurement invariance supported the assumption of equal factor loadings, indicators' intercepts, and factor means. Therefore, we continued to treat the students from both universities as a single sample (i.e., Sample 2).

Next, we conducted another MGCFA on Samples 1 and 2. Starting again with the minimally identified configural model, we found that all factor loadings were significantly different from zero (ps < .001). However, the configural model also showed relatively poor fit (RMSEA = .153, SRMR = .048). To identify sources of misfit, we computed modification indices (Bollen, 1989), which suggested that model fit could be improved by allowing covariance between stress and anxiety (the highest at 89.88). The model fit was significantly improved (likelihood ratio test: p <.001) when we correlated stress and anxiety, RMSEA = .08, SRMR = .029. This modification also makes theoretical sense in that both stress and anxiety are prototypically high arousal affective states created by perceived threats. Hence, we revised the configural model to allow covariance between stress and anxiety. With this modification, the fit statistics indicated a good model fit (see Configural model in Online Supplemental Material [OSM], Table S1).

We then conducted a measurement invariance test to compare the fit of the revised configural model with that of a model in which the factor loadings were constrained to equality across samples (Invariance model). The likelihood ratio test indicated that the former had significantly better fit than the latter, $\Delta\chi^2(4) = 11.07$, $p = .026$. However, other measures of model fit did not consistently indicate a better fit for the configural model (see OSM Table S1). In fact, the invariance model yielded smaller BIC and robust RMSEA statistics than the configural model—indicating somewhat better fit. A Lagrange Multiplier Test on the invariance model revealed that loneliness was the only indicator for which loading constraints significantly altered model fit. Therefore, for ease of interpretation and cross-sample comparisons, we constrained all factor loadings across samples to be equal (see Table 3). In addition, we also constrained all the covariances among factor indicators and the latent factors to equality across groups, and the final model did not show significant changes in fit compared to the model with equality constraints only on factor loadings. In the interests of accuracy and transparency, the OSM reports the results for all analyses using the configural model and partial invariance model as well (in which equality constraints were imposed on all factor loadings except loneliness). Results were identical across models except where otherwise indicated below. To foreshadow: the partial invariance model fully replicated the results from the invariance model and the configural model replicated most of the results shown in the invariance model with the exception that Sample 2 showed slightly different patterns in the mediation effect of perceived positivity resonance on positive mental health when we controlled for positive emotions and frequency of social interactions (see Table S2 in OSM).

Hypothesis Testing

H1: Perceived positivity resonance mediates cross-sectional links between trait resilience and mental health. We hypothesized that perceived positivity resonance would statistically mediate the association between trait resilience and both positive and negative mental health during the COVID-19 pandemic. To test this hypothesis, we ran a multi-group structural equation model in which trait resilience predicted PMH and NMH (correlated residuals included between PMH and NMH), with perceived positivity resonance mediating both associations (see Figure 1). Though the chi-square test of perfect fit was significant, $\chi^2(35) = 129.496$, $p < .001$ (which is common with large sample sizes; Bentler & Bonett, 1980), alternative fit statistics indicated a good fit: robust CFI = .979, robust RMSEA = .070, SRMR = .039. In Sample 1 (N = 574) all pathways in the model were significant. We observed significant direct (B = 1.453, 95%CI = [1.196, 1.709], β = .518, $p < .001$) and indirect effects (B = .275, 95%CI = [.156, .394], β = .098, $p < .001$) of trait resilience on PMH. We also found significant direct (B = -.352, 95%CI = [-.563, -.141], β = –.147, p =.001) and indirect (B = -.123, 95%CI = [-.202, -.043], β = –.05, p =.002) effects of trait resilience on NMH. Thus, the model suggests that individuals who score higher (vs. lower) on trait resilience tend to perceive more positivity resonance, which partially explains their better overall mental health. The same pattern of results emerged in Sample 2 (N = 479). We tested for structural invariance in the mediation model across two samples. We found that the model fit significantly worse when we placed equality constraints on all paths, $\Delta\chi^2(6) = 22.417$, p = .001. A Lagrange Multiplier

Test on the structural invariance model suggested that the regression coefficients of trait resilience on PMH should not be constrained to be equal, as reflected in Figure 1. Allowing coefficients of resilience on PMH to differ across groups resulted in a significant improvement of fit compared to the fully-constrained model, and showed no significant difference in fit compared with the freely estimated model. Using the model in Figure 1, the effect of resilience (ΔB = .484, 95%CI = [.209, .758], $\Delta\beta$ = .142, *p* = .001) on PMH was significantly stronger for Sample 1 (nationwide adults) than Sample 2 (undergraduate students). This difference also resulted in significantly larger total effect (direct plus indirect) of resilience on PMH in Sample 1 compared to Sample 2. Therefore, the final model reported in Figure 1 reflects equality constraints on all paths (raw estimates) except for the regression coefficients of resilience on PMH. We note, however, that although the effects are significantly stronger for Sample 1, they remain statistically significant for Sample 2.

[*Figure 1*. Perceived positivity Resonance Mediates Links Between Trait Resilience and Mental Health]

H2: Perceived positivity resonance at T2 mediates longitudinal links between T1 trait resilience and T3 mental health. Sample 1 included a subset of participants (*n* = 251) who completed T1, T2 and T3 assessments, each time point approximately one month apart, which allowed for longitudinal mediation analyses. Strong measurement invariance was satisfied across time: A likelihood ratio test indicated that there was no significant difference in model fit when we compared the model with equality constraints on the loadings and indicator intercepts of the two mental health factors across time to the model that freely estimated the loadings and indicator intercepts for the two mental health factors across time, $\Delta\chi^2(15) = 17.57$, $p = .28$. The individual latent factors (PMH and NMH) were highly correlated over time (*rs* ranging between .865 and .922), suggesting that PMH and NMH were relatively stable across our three time points. We then fit a structural equation model using FIML to test whether T1 trait resilience predicted mental health measured two months later (at T3) via perceived positivity resonance measured in the interim month (at T2). The same latent variables, PMH and NHM, were included as the outcome variables. The results suggested a good fit of the structural model, $\chi^2(15) = 29.748$, $p = .013$, robust CFI = .991, robust RMSEA = .035, SRMR = .029. The findings from the path analyses showed significant indirect effects of T1 trait resilience through T2 perceived positivity resonance on T3 PMH ($B = .401$, 95%CI = [.205, .597], $\beta = .155$, $p < .001$). However, no significant direct or indirect effects emerged of T1 trait resilience on T3 NMH. Figure 2 presents these results.

[*Figure 2.* Perceived Positivity Resonance Mediates Links Between Trait Resilience and Mental Health, Each Assessed One Month Apart]

Sensitivity Analyses

Accounting for Conceptually Related Variables (Positive Emotions and Quantity of Social Interactions). We had predicted that this mediation would be robust to sensitivity analyses that also included closely related variables. Specifically, we chose positive emotion and quantity of interaction, as they are each well-established contributors to mental health (Fredrickson, 2013b; Pachucki et al., 2015) and because each is a necessary but not sufficient condition for positivity resonance. If perceived positivity resonance is linked with better mental health outcomes independently of the established contributors of positive emotion and social interaction, then this reflects the importance of this amalgam construct for understanding mental health.

H1. First, to test cross-sectionally whether perceived positivity resonance has a distinct effect on mental health, independently from overall positive emotion, we added DRM-based positive emotion scores to the model as a parallel mediator. A likelihood ratio test indicated that this addition improved model fit significantly, $\Delta\chi^2(9) = 391.89$, $p < .0001$. As before, while the chi-square test of perfect fit was significant, $\chi^2(44) = 132.41$, $p < .001$, the other fit statistics indicated a good fit, robust CFI = .982, robust RMSEA = .060, SRMR = .036. Results are presented in Figure S1 (see OSM). In Sample 1, the model showed significant direct effects of resilience on PMH (B = 1.370, 95%CI = [1.107, 1.632], β = .447, p < .001) and NMH (B = -.286, 95%CI = [-.515, -.057], β = –.112, p = .014). We found significant indirect effects of resilience via positive emotion on PMH (B = .301, 95%CI = [.174, .428], β = .098, p < .001) and on NMH (B = -.139, 95%CI = [-.242, -.035], β = –.054, p = .009). When we account for the established mediating effects of overall positive emotion, the indirect effect of resilience via perceived positivity resonance on PMH remained significant, B = .211, 95%CI = [.102, .321], β = .069, p < .001. However, the indirect effect of resilience on NMH became marginally significant, B = -.080, 95%CI = [-.166, .006], β = –.031, p = .067.

In Sample 2, a different pattern of results emerged. After controlling for the effects of overall positive emotion, the effects of perceived positivity resonance on PMH became marginally significant (B = .045, 95%CI= [-.007, .098], β = .016, p =.092) and non-significant on NMH. While positive emotion significantly mediated the relationships between resilience and PMH and NMH in the student sample, perceived positivity resonance did not.

Secondly, to test cross-sectionally whether perceived positivity resonance matters independently of social interaction quantity, we added the frequency of social interactions (number of social episodes on the previous day) as an additional parallel mediator to the model. Adding social interaction frequency as an additional mediator did not significantly alter model fit, which remained good, $\chi^2(54) = 161.592$, $p < .001$, robust CFI = .978, robust RMSEA = .060. In Sample 1 and Sample 2, the pattern of results for perceived positivity resonance (and for overall positive emotion) was the same as Figure S1. Plus, in both samples, no significant link emerged between social interaction frequency and PMH or NMH. (See Figure S2 in OSM).

H2. Building on the longitudinal model depicted in Figure 2, adding T2 overall positive emotion as a parallel mediator did not change the pattern of findings. Above and beyond T2 positive emotion, T2 perceived positivity resonance still significantly mediated the association between T1 resilience and T3 PMH. We found that T2 positive emotion also mediated the effect of T1 resilience on T3 PMH with marginal significance level (see Figure S3). Moreover, adding T2 frequency of social interaction as a third parallel mediator did not change the overall pattern of findings, although the indirect effect of T1 resilience on T3 PMH, through T2 perceived positivity resonance became marginally significant ($p = .053$, see Figure S4). We found no significant direct or indirect effects from T2 frequency of social interactions on either PHM or NMH.

Demographic Covariates (age, gender, ethnicity and geographic region)

H1. Starting with the model depicted in Figure 1, we statistically controlled for age, gender and ethnicity (White vs. Non-white[5]) and geographic region (NC, CA vs. other) simultaneously for every regression path in the cross-sectional model to test whether demographic factors influenced the observed mediating effect of perceived positivity resonance. The addition of these covariates did not change the pattern of results shown in Figure 1.

H2. The same set of covariates were also added to all regression paths in the model depicted in Figure 2. The mediation effect of T1 resilience on T3 PMH via T2 perceived positivity resonance remained significant after controlling for age, gender, ethnicity and geographic region.

Discussion

We surveyed two, independent samples that contributed over 1,000 respondents for cross-sectional analyses. Each described their social and emotional experiences on a typical day during the early phase of the COVID-19 pandemic, when most in the US were under stay-at-home orders. We found that trait resilience was associated with better concurrent overall mental health—both more positive aspects of mental health and fewer negative aspects. Moreover, consistent with Hypothesis H1, we found that perceptions of positivity resonance mediated the cross-sectional associations between trait resilience and both positive and negative mental health. This finding was replicated across samples. Consistent with Hypothesis H2, we also observed the predicted mediating effect of

[5] As we do not have balanced group sizes across ethnicities in both samples, we coded race as a binary variable to achieve more robust results.

perceived positivity resonance when testing a longitudinal mediation model, using data that spanned about two months during the early phase of the pandemic. Key to the interpretation of our longitudinal findings, trait resilience was assessed at T1, perceived positivity resonance at T2, and mental health at T3, following best practices of establishing the temporal precedence for causal (predictor) and intervening (mediating) variables. Thus, as predicted, during a global pandemic, people who scored higher (vs. lower) on a well-validated survey measure of trait psychological resilience appeared to maintain their mental health, both concurrently and over the ensuing two months, in part by finding moments in which they felt enjoyably “in-sync” with others. That is, within their remaining social interactions, they perceived positivity resonance, a marker of high-quality social connection.

We also sought to test the robustness of the observed mediating effect of perceived positivity resonance. Positive emotion and social interaction are well-established contributors to mental health (Fredrickson, 2013b; Pachucki et al., 2015). And, in particular, in past work our team has found positive emotions to mediate the link between trait resilience and negative mental health (Fredrickson et al., 2003; Tugade & Fredrickson, 2007). By definition, positive emotion and social interaction are each necessary, though not sufficient, conditions for the emergence of positivity resonance. As such, it is important to rule out the possibility that positivity resonance is only conducive to mental health insofar as it tracks these other, closely related variables. Thus, we sought to determine whether perceived positivity resonance is conducive to mental health while controlling for overall positive emotion and quantity of social interaction (indexed as the number of social episodes from their past day). In our national sample of adults (Sample

1), we found that perceived positivity resonance continued to mediate the links between trait resilience and both positive and negative mental health even while controlling for both of these possible additional mediators. In our sample of undergraduate students (Sample 2), on the other hand, controlling for overall positive emotion reduced the hypothesized mediating effect of perceived positivity resonance to marginal significance. (Marginal significance was observed for the models that imposed measurement invariance and partial invariance, whereas the effect dropped to non-significance for the configural model.) Taken as whole, our results imply that, moments in one's day marked by collective positive affect plus mutual care and synchrony are conducive to flourishing mental health independently of overall positive emotion and quantity of social interaction experienced that same day.

Our results thus supported our hypotheses. Trait resilience appears to be linked with better overall mental health in part because people who score higher (vs. lower) on a self-report measure of resilience find or forge more moments in which they feel a high-quality connection with others. While past research has revealed the importance of positive affect for mental health, the current results highlight the importance of *collective* positive affect that also includes feelings of mutual care and synchrony. Moreover, while other research has established the importance of social interaction for mental health, these results suggest that what matters is not the *quantity* (i.e., the number) of interactions, but their *quality* (i.e., the positivity resonance experienced therein).

Limitations and Future Directions

The data from this study allowed us to examine both cross-sectional and longitudinal associations between our variables of interest. Nevertheless, because this was not a randomized, controlled experiment, we are unable to draw causal conclusions about the links between perceived positivity resonance and mental health. However, these findings point to promising positive psychology interventions that could be tested with future longitudinal randomized experimental designs. With the right behavioral nudges or structural support, people might be able to improve their own mental health (and that of others) by creating more moments of positivity resonance in daily life.

Additionally, although we have longitudinal data, we do not have pre-pandemic data for participants in this study. We were thus unable to assess whether and to what degree people's mental health, quantity of social interaction, and levels of positivity resonance changed as a result of the COVID-19 outbreak and ensuing lockdown. The fact that our data were collected during the early months of the COVID-19 pandemic also means that our findings may not generalize beyond that context or similar ones. Although, at the time of writing, such contexts seemed likely to recur during the remainder of 2020, and likely 2021, as well.

Our Sample 1 participants were recruited through Amazon's Mechanical Turk. While the workers on this platform are more demographically representative than typical undergraduate samples, this was nevertheless a convenience sample and not a nationally representative sample. Another potential limitation of the use of Mechanical Turk is "non-naïveté" (Miller et al., 2017). Many workers on the platform participate in multiple research studies (Difallah et al., 2018), meaning that they may have previously encountered some of the measures used in this study. Given that none of our measures were performance tests (where previous exposure might bias responses), however, this possibility is unlikely to constitute a significant limitation on our results.

While in many ways a strength, the fact that our results were based on participants who resided virtually anywhere in the US is also a potential limitation on generalizability insofar as different regions of the US had implemented different responses to the pandemic, which could conceivably influence the associations between our variables of interest. We note, however, that including geographic region as a covariate (given our sample, this was coded as California, North Carolina, or other) did not alter the pattern of results, either cross-sectional or longitudinal.

Another limitation of this study was the reliance on explicit and retrospective self-report measures. However, as indicated previously, the self-report measure of trait resilience we used has been shown to predict meaningful individual differences in physiological (Lü et al., 2016; Souza et al., 2007, 2013; Tugade & Fredrickson, 2004) and neurological responding (Waugh et al., 2008) indicative of an adaptive capacity to cope with and recover from negative experiences. Moreover, the Day Reconstruction Method (DRM), used here to assess perceived positivity resonance, overall positive emotion, and social interaction quantity, has been found to minimize retrospection and response biases, and to generate high-quality data on par with experience sampling methods (Grube et al., 2008; Kahneman et al., 2004; Stone et al., 2006). DRM-based perceived positivity resonance scores in this study were based on participant ratings of over 5,000 social episodes. That is, the average participant assessed the affective quality of five or so social episodes from their previous day, from which we calculated person-level aggregates. Nevertheless, it will be valuable for future studies to corroborate these findings using reports from multiple interactants and/or behavioral indicators of positivity resonance (Otero et al., 2019), or its physiological correlates (Chen et al., 2020). We note, however, that the risk-benefit ratio for collecting in-person assessments of the behavioral and physiological markers of positivity resonance may be unacceptably high during a pandemic.

Conclusion

In the wake of the COVID-19 outbreak, “lockdowns” and “stay at home” orders severely restricted individuals’ opportunities for socializing. While important for slowing the spread of disease, such measures predictably come with serious costs to individual well-being. Our findings showed that people who score higher on trait resilience experience better overall mental health—more of its positive aspects and less of the negative ones—compared to those who score lower. These mental health benefits arise in part because—even during times of “social distancing”—these individuals are finding or forging more experiences of high-quality social connection, moments characterized by the novel construct of positivity resonance. Our results suggest that these moments matter independently of overall positive emotion (previously shown to play a similar role), indicating that these moments of co-experienced positivity are especially powerful sustainers of mental health. Our results also suggest that social interaction is, in one respect, like chocolate: quality is more important than quantity. It seems that what matters is not how frequently one interacts with others, but how much shared positivity, warmth, and synchrony is found within the interactions one has. This is good news at a time when “flattening the curve” requires limiting the quantity of social interaction.

Table 1. Correlation Tables of Variables of Interest Grouped by Samples.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	n Sample 1	n Sample 2
1. Resilience		.29***	.53***	.54***	-.19***	-.15***	-.12**	-.16***	.38***	.07	574	479
2. PosRes	.16***		.44***	.40***	-.21***	-.26***	-.06	-.18***	.49***	.17***	536	481
3. MHC	.38***	.25***		.75***	-.46***	-.34***	-.26***	-.36***	.49***	.13**	573	479
4. mMEMS	.35***	.27***	.63***		-.46***	-.34***	-.22***	-.33***	.45***	.14**	572	480
5. Depression	-.21***	-.19***	-.57***	-.50***		.69***	.70***	.76***	-.22***	-.07	575	483
6. Loneliness	-.18***	-.21***	-.36***	-.36***	.59***		.61***	.67***	-.21***	-.16***	575	483
7. Anxiety	-.14**	-.10*	-.41***	-.31***	.67***	.50***		.83***	-.11**	-.05	575	483
8. Stress	-.11*	-.14**	-.43***	-.36***	.68***	.50***	.77***		-.19***	-.06	575	483
9. PA	.26***	.45***	.42***	.39***	-.37***	-.30***	-.27***	-.29***		.12**	575	484
10.Nsocial	.05	.07	.11*	.12**	-.04	-.10*	.01	-.01	.13**		536	482

Note. PosRes=Positivity Resonance; MHC=Mental Health Continuum Scale; mMEMS= modified Multidimensional Existential Meaning Scale; PA=Positive Affect; Nsocial=Number of Social Episodes; n= number of observations for each variable in the sample. Correlation coefficients estimated from Sample 1 (MTurk, N=575) were reported above the diagonal. The correlation coefficients estimated from Sample 2 (Student, N=484) were reported below the diagonal. *p<.05, **p<.01, ***p<.001

Table 2. Descriptive Statistics and Sample Differences in Variables of Interest and Demographic Factors.

Descriptive and Independent Samples T-tests

Positive Mental Health Outcomes	*M*		*SD*		Independent Samples T-test Results
	Mturk	Student	Mturk	Student	
Mental Health Continuum (1-6)	4.16	3.92	1.01	.94	*t*(1050)=3.98, p<.0001
mMEMS(1-7)	5.37	5.25	1.05	.97	*t*(1050)=1.88, p=0.059

Negative Mental Health Outcomes	*M*		*SD*		Independent Samples T-test Results
	Mturk	Student	Mturk	Student	
Depression (1-5)	2.07	2.13	1.14	1.03	*t*(1049.9)=-0.87, p=0.38
Loneliness (1-5)	2.28	2.51	1.19	1.01	*t*(1056)=-3.40, p=.0007
Stress (1-5)	2.33	2.86	1.08	1.1	*t*(1056)=-7.89, p<.0001
Anxiety (1-5)	2.36	2.53	1.09	1.03	*t*(1041.6)=-2.63, p=.0009
Age	36.69 (18-74)	20.45 (18-55)	11.54	2.89	t(657.51)=32.52, p<.001
					Chi-Square Test of Independence
Gender	285(M) 287(F)	151 (M) 329 (F)	N/A	N/A	$\chi^2(1) = 35.53, p < .001$
Ethnicity	~40% White	~20% White; ~20% Asian	N/A	N/A	$\chi^2(7) = 210.02, p < .001$

Table 3. Factor Loadings Estimated from Multi-Group Confirmatory Factor Analyses for the Positive and Negative Mental Health Outcomes.

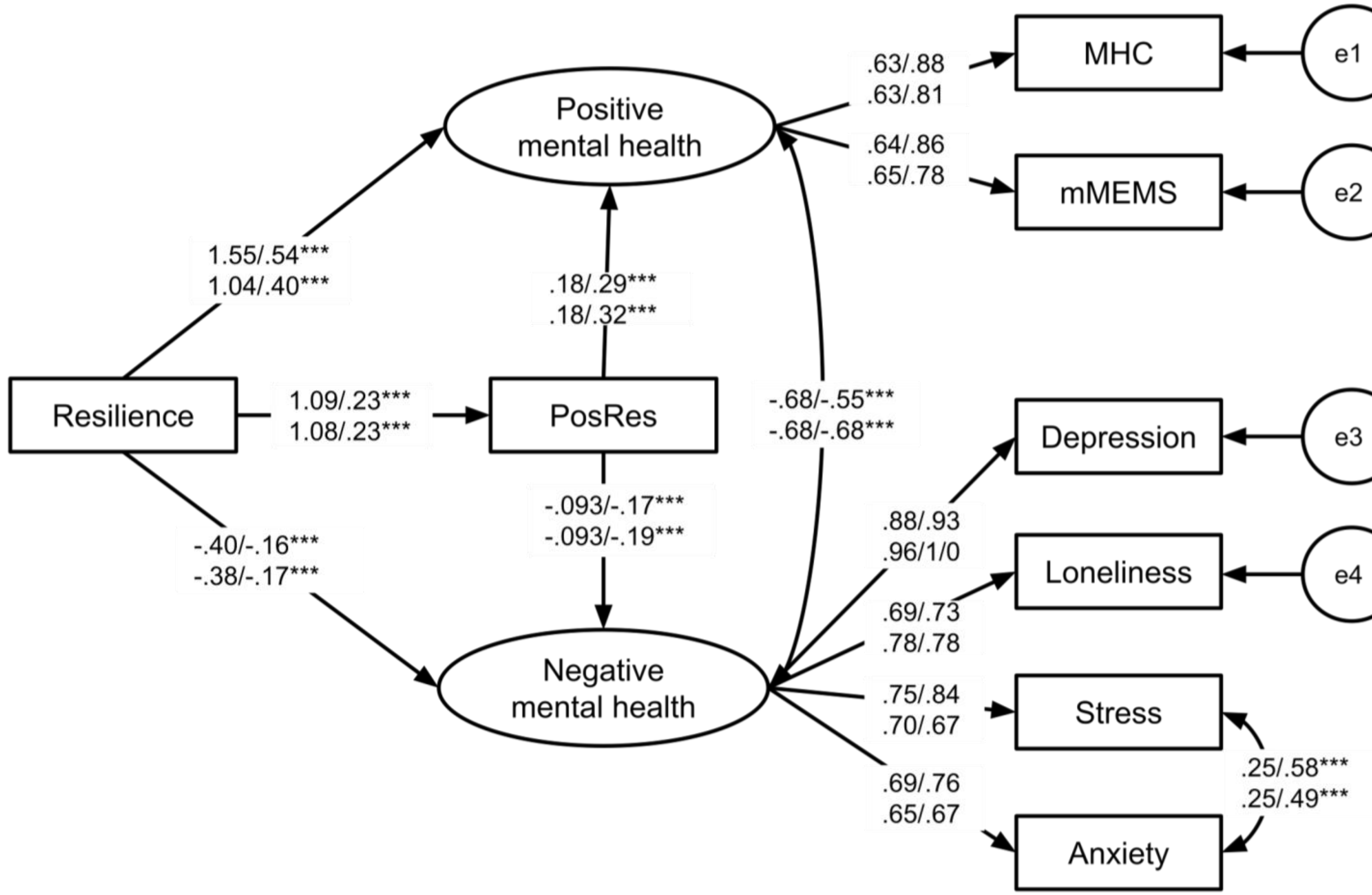
Multi-group Confirmatory Factor Analyses

Positive Mental Health Outcomes	*M* (total)	*SD* (total)	Factor Loadings		
			Sample 1 (*N* = 575)	Student (*N* = 484)	Constrained
Mental Health Continuum (1-6)	4.05	0.98	.786(.856) ***	.786(.841) ***	.757(.817) ***
mMEMS (1-7)	5.32	1.02	.848(.882) ***	.734(.753) ***	.766(.777) ***

Negative Mental Health Outcomes	*M* (total)	*SD* (total)	Factor Loadings		
			Sample 1 (*N* = 575)	Student (*N* = 484)	Constrained
Depression (1-5)	2.10	1.09	1.007(1.036) ***	1.007(.976) ***	1.003(.992) ***
Loneliness (1-5)	2.38	1.12	.900(.880) ***	.698(.696) ***	.818(.778) ***
Stress (1-5)	2.57	1.12	.683(.741) ***	.774(.702) ***	.724(.669) ***
Anxiety (1-5)	2.44	1.06	.637(.685) ***	.697(.685) ***	.667(.661) ***

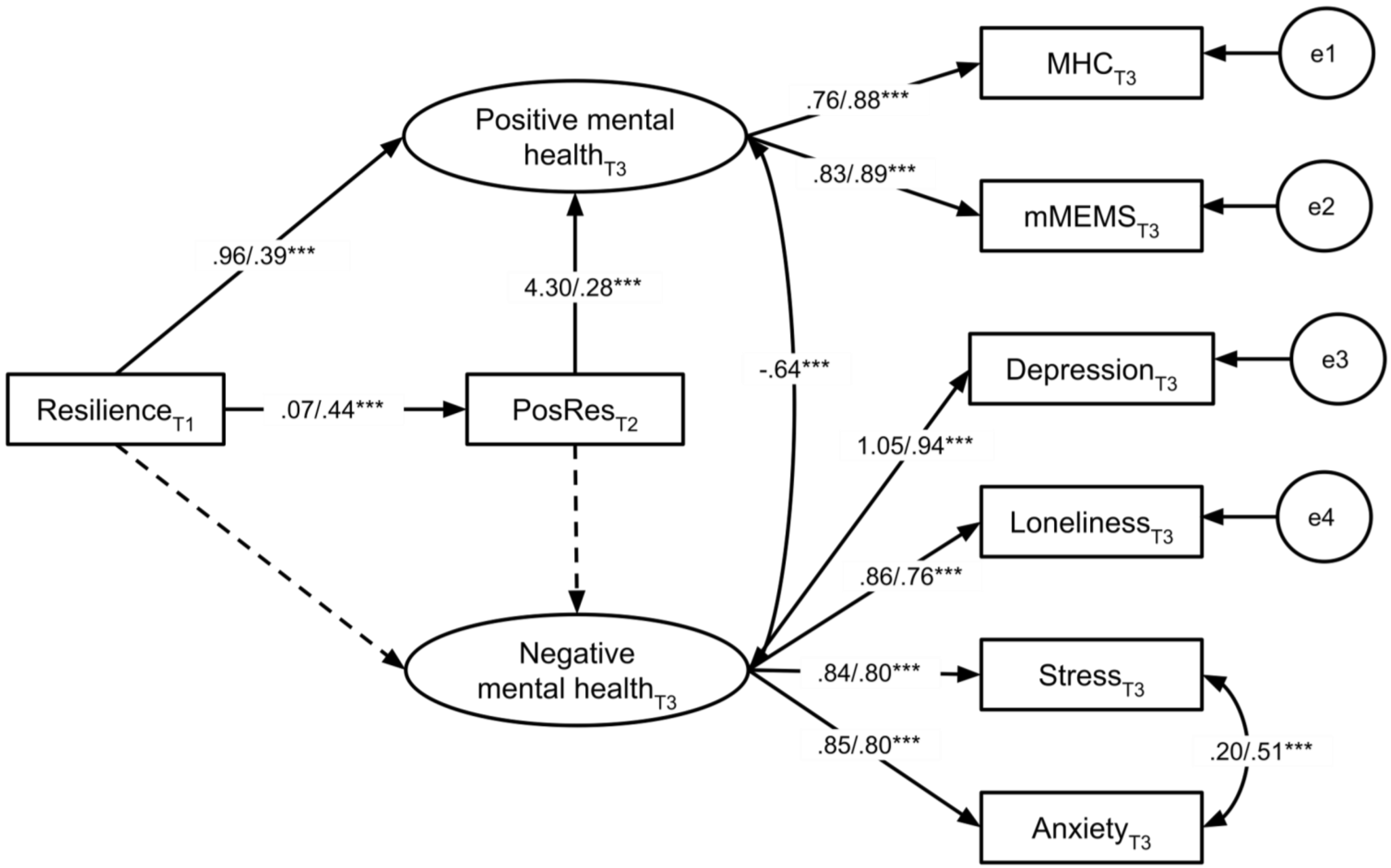
Note. mMEMS= modified Multidimensional Existential Meaning Scale; Factor loadings are raw estimates and standardized estimates were included in the parentheses. Anxiety and stress were allowed to covary in the model to improve model fit. *$p<.05$, **$p<.01$, ***$p<.001$

Figure 1. **Positivity Resonance Mediates Links Between Resilience and Mental Health**



Notes. MHC=Mental Health Continuum Scale; mMEMS= modified Multidimensional Existential Meaning Scale; Both raw and standardized coefficient and covaraince estimates are reported, respectively, separated by the "/" character within the same line of text (raw/standardized). Regression coefficients that differed across groups are reported for both samples in a column of text, with the upper coefficients for Sample 1 and the lower ones for Sample 2. †*p*<.10, **p*<.05, ***p*<.01, ****p*<.001

Figure 2. **Positivity Resonance Mediates Links Between Resilience and Mental Health One Month Later.**



Note. N=574. MHC=Mental Health Continuum Scale; mMEMS= modified Multidimensional Existential Meaning Scale; Both raw and standardized coefficient and indicator covariance estimates are reported, respectively, separated by the "/" character within the same line of text (raw/standardized). Both latent variables are standardized. The covariance reported between PMH and NMH reflected the correlation. †p<.10, *p<.05, **p<.01, ***p<.001

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SUPPLEMENTARY MATERIAL
for Prinzing, Zhou et al.'s
Staying 'In Sync' with Others During COVID-19:
Positivity Resonance Mediates Cross-Sectional and Longitudinal Links between Trait Resilience and Mental Health

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Alternative Equality Constraints on Multi-group CFA

The measurement invariance test suggests partial weak invariance in two latent factors: positive mental health (PMH) and negative mental health (NMH). Below we reported the results of each hypothesis using 1) the partial invariance model where all loadings are constrained to be equal across samples except the loadings of loneliness; 2) the configural model where all factor loadings are freely estimated. Table S2. compares the pattern of results for these additional models plus the invariance model, which was reported in the manuscript.

H1: Positivity resonance statistically mediates the relationships between resilience and positive and negative mental health outcomes during the COVID-19 pandemic cross-sectionally. Based off the partial invariance model to estimate the latent factors positive and negative mental health, the model showed good fit, $\chi^2(35) = 121.505$, $p < .001$ (common given the large sample size), robust CFI = .986, robust RMSEA = .067, SRMR = .039. The results indicated that the mediating role of positivity resonance on the link between resilience and mental health (both positive and negative) were found in both samples. In Sample 1 (N=574), we found significant direct effect ($B = 1.50$, 95%CI = [1.252, 1.747], $\beta = .51$, $p < .001$) and significant indirect effect ($B = .284$, 95%CI = [.162, .406], $\beta = .097$, $p < .001$) of resilience on PMH. Significant direct effect ($B = -.348$, 95%CI = [-.555, -.140], $\beta = -.143$, $p < .001$) and indirect effect of resilience ($B = -.123$, 95%CI = [-.201, -.044], $\beta = -.051$, $p = .002$) on NMH were also found. Same result patterns emerged in Sample 2 ($N = 479$).

Based off the configural model (freely estimated loadings across samples), the results suggested a good fit, $\chi^2(30) = 116.334$, $p < .001$, robust CFI = .980, robust RMSEA = .073, SRMR = .031. Same associations among resilience, positivity resonance and mental health were replicated using the configural model.

Sensitivity Analyses

This predicted mediation effect obtains even when accounting for the overall amount of positive emotion that individuals experience. When we adopted the partial variance model for the latent mental health outcomes, in Sample 1 ($N = 574$), results suggested significant direct effects ($B = 1.383$, 95%CI = [1.117, 1.649], $\beta = .443$, $p < .001$) and indirect effects ($B = .227$, 95%CI = [.114, .341], $\beta = .073$, $p < .001$) of resilience on PMH. Direct effects of resilience ($B = -.285$, 95%CI = [-.515, -.054], $\beta = -.111$, $p = .015$) and positivity resonance ($B = -.058$, 95%CI = [-.116, -.000], $\beta = -.108$, $p = .049$) remained significant on NMH, but the indirect effect of resilience via positivity resonance became marginally significant when we controlled for positive emotions ($B = -.088$, 95%CI = [-.179, .003], $\beta = -.034$, $p = .059$). The mediation effect of positivity resonance on PMH obtains even when we control for the overall amount of positive emotion in Sample 1. These findings were not fully replicated in Sample 2 (N = 479). We found significant direct effects of resilience on both PMH and NMH whereas only the indirect effect of resilience on PMH was marginally significant ($B = .059$, 95%CI = [-.006, .124], $\beta = .021$, $p = .074$). We replicated the findings using the configural model except that the indirect effect of resilience on PMH in Sample 2 was no longer significant.

This predicted mediation effect obtains even when accounting for the overall quantity of social interactions. Adding the number of social episodes as a parallel mediator using the partial variance measurement model does not change the findings from previous model when we only accounted for positive emotions. No significant direct effects or indirect effect of the number of social episodes were found on mental health. Findings from previous model when only positive emotions were accounted for obtained using the configural model as well.

Demographic covariates. Based off the model reported in Figure 1, we then controlled for age, gender, ethnicity and states using both partial invariance and configural models. All regression paths remained significant after we controlled for demographic covariates.

Supplementary Tables and Figures

Table S1. Candidate models for multi-group CFA on positive and negative mental health

Model	χ^2	*df*	*p*	Robust RMSEA	Robust CFI	SRMR	AIC	BIC
Configural	63.54	14	< .001	.080	.987	.029	15011	15210
Invariance	76.598	18	< .001	.076	.985	.041	15016	15195
Partial Invariance	65.171	17	< .001	.071	.988	.030	15007	15190

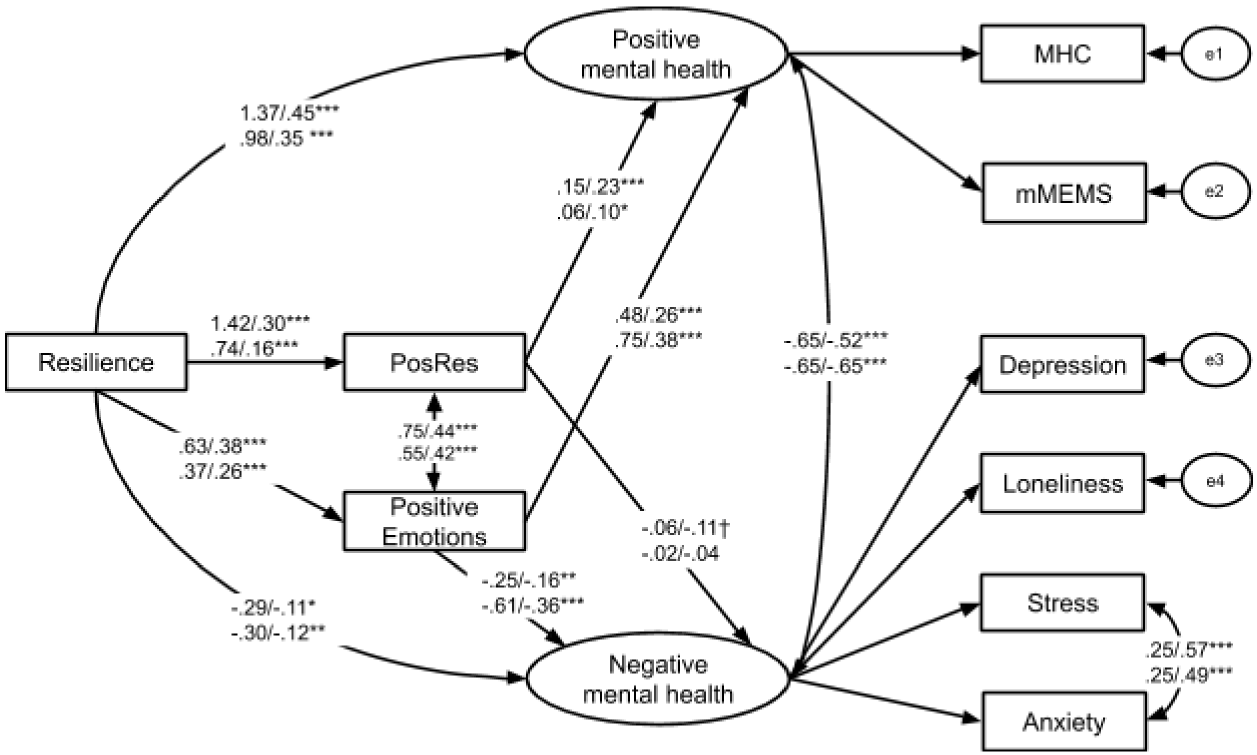
Note. The configural model is includes no equality constraints on parameters across samples. The invariance model constrains all factor loadings, and the partial invariance model constrains the factor loadings apart from loneliness. χ^2, *df*, and *p* = Likelihood ratio test of perfect fit; Robust RMSEA = root mean square error of approximation corrected for standard errors; CFI = confirmatory fit index corrected for standard errors; SRMR= Standardized Root Mean Square Residual; AIC = Akaike's information criterion; BIC = Bayesian information criterion.

Table S2 Summary of Results for Hypotheses on the Mediation Effect of Positivity Resonance Cross-sectionally and Longitudinally

Hypothesis	Configural		Partial Invariance		Invariance		Longitudinal
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	
H1							
Resilience → PosRes→ PMH	✓	✓	✓	✓	✓	✓	✓
Resilience → PosRes→ NMH	✓	✓	✓	✓	✓	✓	ns
Sensitivity Analyses							
H1 controlling for Positive Emotions	Positive emotions significantly mediate the association between resilience and mental health across all models						
Resilience → PosRes→ PMH	✓	ns	✓	Marginally Significant	✓	Marginally Significant	✓
Resilience → PosRes→ NMH	Marginally Significant	ns	Marginally Significant	ns	Marginally Significant	ns	ns
H1 controlling for Positive Emotions + Frequency of Social Interactions	Frequency of social interaction do not have direct or indirect effects on mental health.						

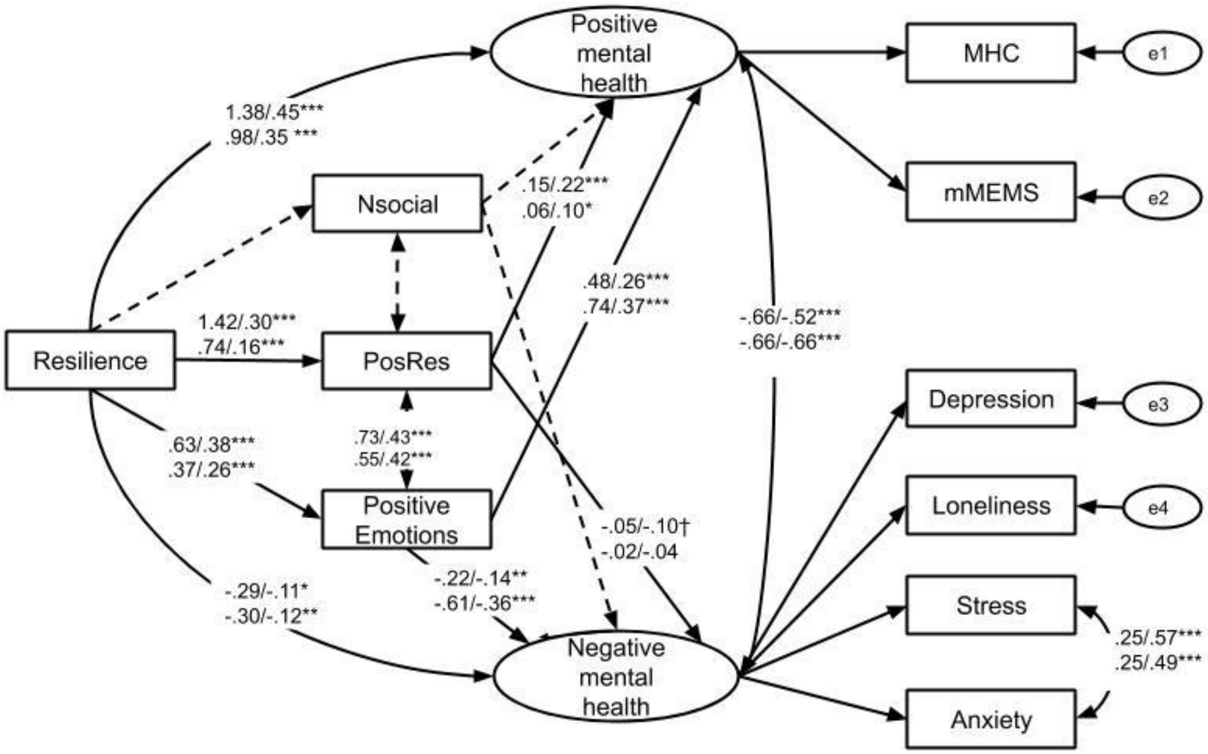
Resilience → PosRes→ PMH	✓	ns	✓	Marginally Significant	✓	Marginally Significant	✓
Resilience → PosRes→ NMH	Marginally Significant	ns	Marginally Significant	ns	Marginally Significant	ns	ns
H1 controlling for demographics							
Resilience → PosRes→ PMH	✓	✓	✓	✓	✓	✓	✓
Resilience → PosRes→ NMH	✓	✓	✓	✓	✓	✓	ns

Figure S1. **Positivity Resonance Statistically Mediates Links Between Resilience and Mental Health Independently of Positive Affect (cross-sectional)**



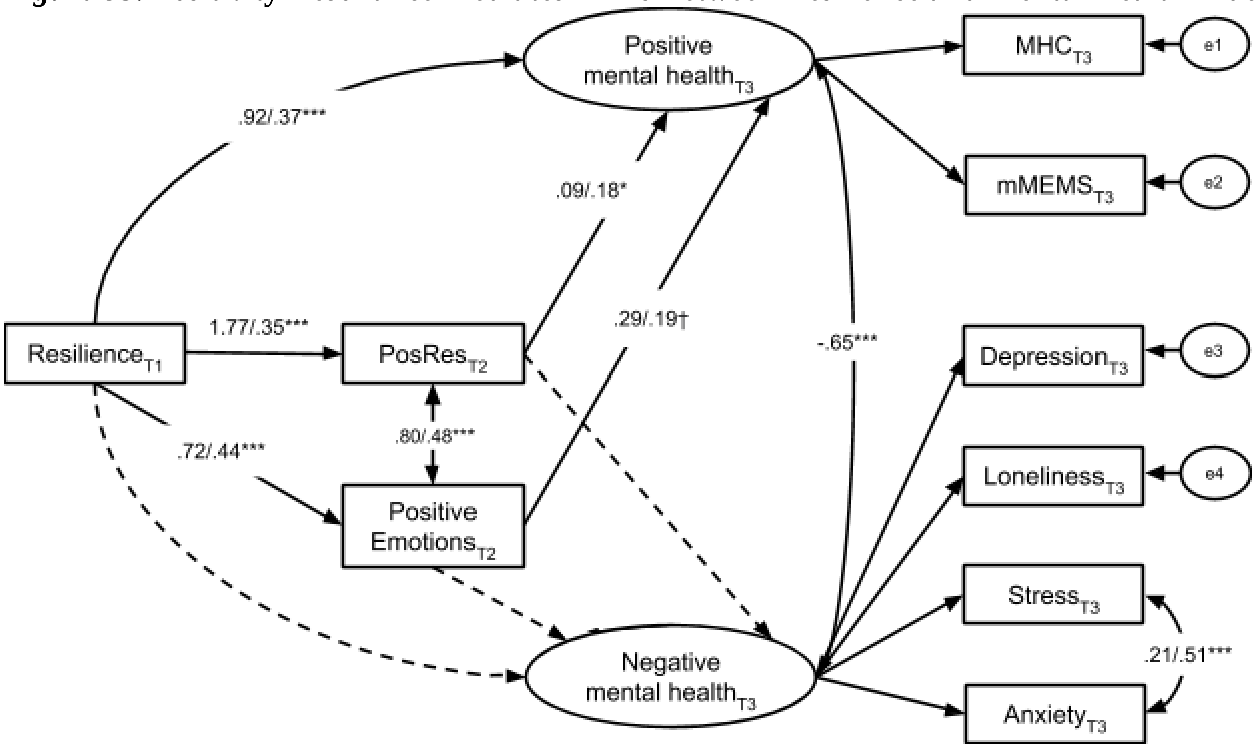
Notes. PosRes= Positivity Resonance; MHC=Mental Health Continuum; mMEMS= modified Multidimensional Existential Meaning Scale. Both standardized and raw coefficient estimates were reported separately by slash in the figure. The loadings of the latent variables stay mostly the same as previous model reported in Figure 1. To simplify the diagram, factor loadings were omitted here. The former ones are the raw estimates and the latter ones are the standardized coefficients. Regression coefficients differed across groups and were reported for both samples. The upper ones indicated the regression coefficients for Sample 1 and the lower ones indicated the regression coefficients for Sample 2. † p < .10, * *p* < .05, ** *p* < .01, *** *p* <.001

***Figure S2.* Positivity Resonance Statistically Mediates Links Between Resilience and Mental Health Independently of Positive Emotion and Social Interaction Quantity (cross-sectional)**



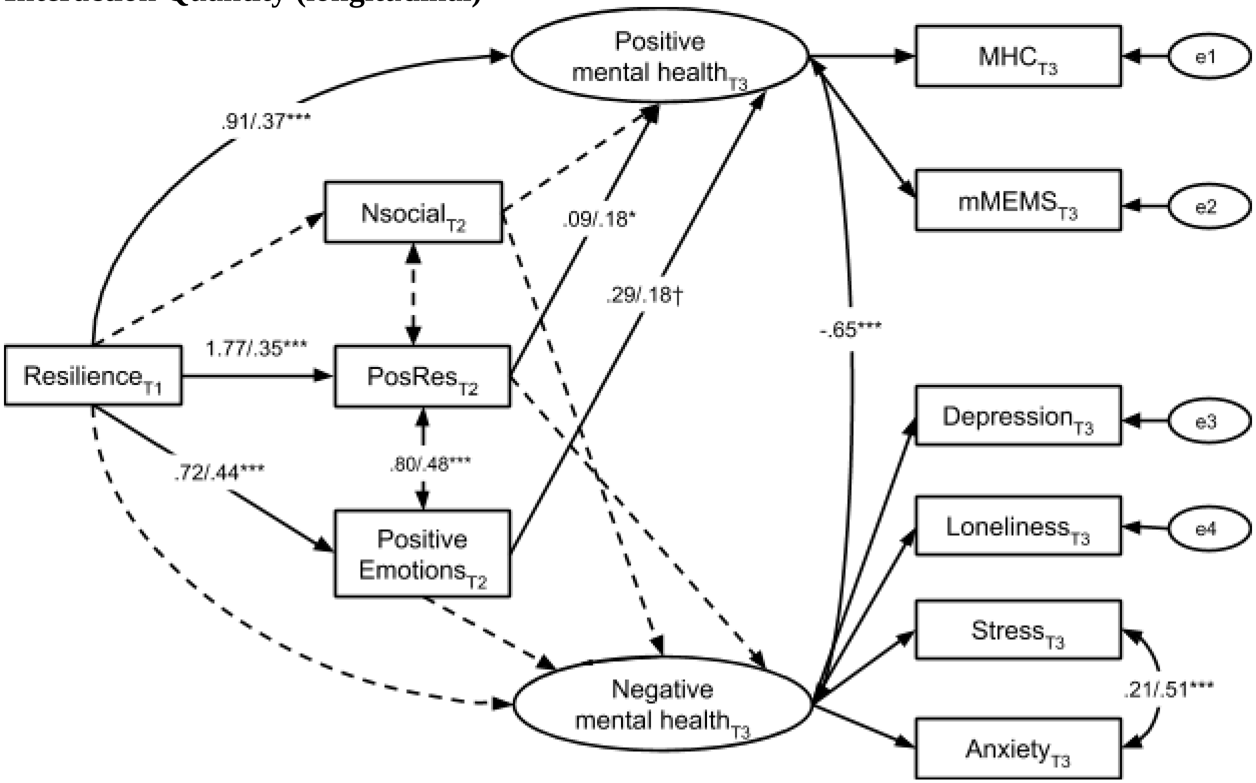
Notes. NSocial=total number of social episodes during the day; PosRes= Positivity Resonance; MHC=Mental Health Continuum Short Form; mMEMS= modified Multidimensional Existential Meaning Scale. The loadings of the latent variables stay mostly the same as previous model reported in Figure 1. To simplify the diagram, factor loadings were omitted here. Both standardized and raw coefficient estimates were reported separately by slash in the figure. The former ones are the raw estimates and the latter ones are the standardized coefficients. Regression coefficients differed across groups and were reported for both samples. The upper ones indicated the regression coefficients for Sample 1 and the lower ones indicated the regression coefficients for Sample 2. † p < .10, * p < .05, ** p < .01, *** p < .001

***Figure S3.* Positivity Resonance Mediates Links Between Resilience and Mental Health Independently of Positive Emotion (longitudinal)**



Notes. PosRes= Positivity Resonance; MHC=Mental Health Continuum; mMEMS= modified Multidimensional Existential Meaning Scale. Both standardized and raw coefficient estimates were reported separately by slash in the figure. The loadings of the latent variables stay mostly the same as previous model reported in Figure 2. To simplify the diagram, factor loadings were omitted here. The former ones are the raw estimates and the latter ones are the standardized coefficients. Regression coefficients differed across groups and were reported for both samples. The upper ones indicated the regression coefficients for Sample 1 and the lower ones indicated the regression coefficients for Sample 2. † p < .10, * p < .05, ** p < .01, *** p < .001

Figure S4. **Positivity Resonance Mediates Links Between Resilience and Mental Health Independently of Positive Emotion and Social Interaction Quantity (longitudinal)**



Notes. NSocial=total number of social episodes during the day; PosRes= Positivity Resonance; MHC=Mental Health Continuum Short Form; mMEMS= modified Multidimensional Existential Meaning Scale. The loadings of the latent variables stay mostly the same as previous model reported in Figure 1. To simplify the diagram, factor loadings were omitted here. Both standardized and raw coefficient estimates were reported separately by slash in the figure. The former ones are the raw estimates and the latter ones are the standardized coefficients. Regression coefficients differed across groups and were reported for both samples. The upper ones indicated the regression coefficients for Sample 1 and the lower ones indicated the regression coefficients for Sample 2. † p < .10, * $p < .05$, ** $p < .01$, *** $p < .001$