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How the Affective Quality of 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
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Abstract

Although behaviors such as handwashing, mask wearing and social distancing are known to limit viral spread, early in the COVID-19 pandemic, many individuals in the United States did not adopt them. The Positivity Resonance Theory of co-experienced positive affect (Fredrickson, 2016) holds that shared pleasant states that include the key features of mutual care and a sense of oneness through behavioral synchrony, function to build prosocial tendencies (e.g., self-transcendent and other-oriented dispositions of felt unity, empathy, altruism and general positivity toward humanity). We tested the theory-driven hypothesis that prosocial tendencies are associated with high-quality social connections characterized by the affective state of *positivity resonance*, and in turn account for behaviors to slow the spread of COVID-19. We measured perceived positivity resonance at the level of social episodes either during the COVID-19 pandemic (Study 1, $N = 1059$, April-May 2020) or before it (Study 2, $N = 227$, March-November 2019). In both studies, cross-sectionally and prospectively, results suggest that perceived positivity resonance had a positive indirect effect on self-reported hygienic behaviors (e.g., handwashing & mask-wearing), which was mediated by a latent measure of prosocial tendencies. Sensitivity analyses confirmed these mediation effects to be independent of competing predictors of prosocial tendencies (e.g., overall positive and negative affect, frequency of social interaction) and competing predictors of health behaviors (e.g., political orientation, high-risk status, illness symptoms). Effects for social distancing were mixed. Overall, findings are consistent with the view that positivity resonance builds self-transcendent prosocial tendencies that motivate behaviors to protect community health.

Keywords: positive psychology; broaden-and-build theory; health behavior; emotion

In step with the rise of large-scale civilizations, humans have endured pandemics, a reality made salient in early 2020 as COVID-19, the disease caused by SARS-CoV-2, reached multiple continents. Absent vaccines, societies rely on people's behaviors to curb the spread of disease. To the extent that government-mandated actions are lacking or inconsistent, people's intrinsic motivation to comply with behavioral recommendations from public health officials becomes a vital determinant of disease spread. The United States (US), however, faced both cultural and socio-political barriers to gaining immediate and widespread changes in people's daily health-protective behaviors. Research that investigates factors that shape people's intrinsic motivation to adopt behaviors to protect community health thus becomes essential. We hypothesize that high-quality social connections marked by co-experienced positive affect bear a unique association with prosocial tendencies that are tied to behaviors that reduce viral spread, such as handwashing, mask wearing, and social distancing.

1. Barriers to Coordinated and Widespread Behavior Change

As an individualistic culture and a nation that values personal freedom over duty or security, the US faced cultural barriers to coordinated action at the onset of widespread community transmission of COVID-19 (Van Bavel et al., 2020). Lacking a unified federal response, state and local governments were left to make their own decisions about whether to implement 'stay-at-home' orders and mandate face coverings. Resistance to new public policy (re: social distancing, mask wearing) appears typical in countries with 'loose' government and social structures, in which high tolerance exists for deviations from social norms and rules (Gelfand et al., 2011; Van Bavel et al., 2020). Theory suggests that infectious diseases imposed selection pressures on human behavior, leading to the evolution of the behavioral immune system, a set of psychological mechanisms and social behaviors that serve as pathogen defense (e.g., ethnocentrism, conformity). These adaptations are less pronounced in individualistic cultures, which have less history of pathogen prevalence (Fincher et al., 2008; Schaller & Park, 2011). Yet the US has stood out globally, even compared to its other Western (i.e., individualistic) counterparts, in its inability to control the spread of COVID-19 (Diamond & Wheaton, 2020; Bremmer, 2020). Another barrier to successful containment is that the US COVID-19 response became increasingly politicized during a time of already high affective political polarization (Boxell et al., 2020). Affective political polarization, which refers to distrust and dislike of those from opposing political parties, posed a strong barrier to coordinated action, due to opposing groups holding different beliefs about the threat of COVID-19 and mask-wearing mandates (Van Bavel et al., 2020; Moncus & Connaughton, 2020; Igielnik, 2020). Because pandemics can recur, and widespread action and cooperation is essential to contain

viral spread, it is imperative to understand social and psychological factors that support the enactment of behaviors

that promote public health in cultures that are both "loose" and polarized.

2. Co-experienced Positive Affect Builds Intrinsic Motives for Infection-reducing Behaviors

One way to get people to adopt infection-reducing behaviors is to increase their concern for others, so that

other-oriented concern outweighs personal desires or perceived threats to cultural or socio-political values

(Pfattheicher et al., 2020). We consider *prosocial tendencies* to represent a range of positive, action-oriented

dispositions, moral habits, and behaviors that transcend self-interest to promote or maintain communities. Prosocial

tendencies are not fixed habits, but rather are social resources that may build up or erode over time. An offshoot of

Broaden-and-Build Theory (1998, for a review, see Fredrickson, 2013), the Positivity Resonance Theory of co-

experienced positive affect, holds that positive affect collectively experienced between and among individuals can

build such resources to a greater degree than positive affect that is experienced individually (Fredrickson, 2016).

Specifically, a particular subtype of co-experienced positive affect, termed *positivity resonance*, occurs when two or

more individuals show three key features across multiple emotion-response systems: (a) shared positive affect

(experiential), (b) caring nonverbal synchrony (behavioral), and (c) biological synchrony (physiological). These

moments of high-quality social connection can emerge with the aid of perceived safety and real-time sensory

connection between and among close friends, romantic partners, coworkers, acquaintances, or even complete

strangers. The degree to which individuals experience or express positivity resonance or show biological synchrony

during co-experienced positive affect has been found to predict levels of personal and interpersonal resources, such

as mental health and relationship satisfaction, and does so independently of overall positive emotions and quantity of

social interaction (Brown et al., in press; Chen et al., 2020; Major et al., 2018; Otero et al., 2019).

Individuals who frequently experience positivity resonance are also theorized to have accrued resources

that transcend self-interest to promote other-oriented concern and behavior (i.e., prosocial tendencies). We posit that

recurrent positivity resonance builds at least four interrelated *prosocial tendencies*, namely spirituality, empathy,

altruism, and love of humanity, each of which is theoretically and/or empirically linked to features of positivity

resonance. *Spirituality,* defined non-theistically as a feeling of interconnectedness and unity to all of life (Piedmont,

1999; Pargament, Oman, Pomerleau & Mahoney, 2017), is known to be triggered by self-transcendent positive

emotions (Van Cappellen et al., 2013; Saroglou, et al., 2008). *Empathy,* defined as understanding and vicariously

sharing another's emotions and feeling concern for the other in their time of suffering, is closely aligned with the

mutual care feature of positivity resonance (Preston & De Wall, 2002) and its development has been linked to warm and synchronous interactions between infants and their caregivers (Levy et al., 2019). Relatedly, *altruism*, defined as both the feeling of compassion and the actions of helping or giving (Lapseley & Narvaez, 2014) can be produced between strangers simply through synchronous movements (Valdesolo & DeSteno, 2011). Finally, we theorize that *love of humanity*, defined as positive feelings toward people in general coupled with beliefs that people are typically kind, good, and helpful (Campos et al., 2002; Sprecher & Fehr, 2005), predisposes individuals to approach and be open to a range of interaction partners, which can subsequently reinforce positive feelings toward humanity in an upward spiral dynamic (e.g., Fredrickson & Joiner, 2018). While each of these prosocial tendencies has been linked to one or more of the others in past research (e.g., spirituality, love of humanity, and altruism; Nai et al., 2018), the present work is the first to link these four specific prosocial tendencies to one another and to positivity resonance.

Our theory-driven prediction is that positivity resonance motivates infection-reducing behavior implicitly and indirectly, as mediated by a suite of prosocial tendencies. The present work thus complements and extends existing theory and research on the role of positive affect and nonconscious processes in health behavior maintenance (e.g., Custers & Aarts, 2005; Van Cappellen et al., 2017). Whereas no published studies have yet examined the first link in this prediction (i.e., that from positivity resonance to prosocial tendencies), a number of published studies have supported the second link (i.e., from prosocial tendencies to infection-reducing behaviors). Empathy, for instance, has been investigated as a resource to increase health-related behaviors in pandemics and health care settings. Specifically, early in the COVID-19 pandemic, four studies (with samples from the US, United Kingdom and Germany) found experimentally-induced empathy for vulnerable populations to produce motivation to adhere to social distancing and mask wearing guidelines (Pfattheicher et al., 2020). Data gathered during past global health crises (i.e., SARS, West Nile) have also linked empathy to taking recommended health precautions (Puterman et al., 2009; Lee-Baggley et al., 2004). Plus, a prospective study of health care workers who received a 4-week empathy induction in their hospital ward (i.e., pre-tested posters of empathy-related photographs and psychoeducation on the benefits of empathy in patient interactions) found increased use of hand sanitizer relative to a control ward (Sassenrath et al., 2016). Beyond empathy, altruism has also been shown to motivate public health behaviors that protect others. Specifically, altruistic individuals are more likely to get vaccinated and be motivated by protecting others (Shim et al., 2012). Relatedly, educating people about herd immunity together with the social benefits of vaccination increases people's willingness to vaccinate (Betsch et al., 2017; Betsch et al., 2013). While

we are not aware of research that links non-theistic spirituality and love of humanity with infection-reducing health behaviors, the studies on altruism and empathy support our prediction that prosocial tendencies motivate individuals to engage in behaviors that protect public health during epidemics and pandemics.

3. The Current Research

Consistent with the Positivity Resonance Theory of co-experienced positive affect, we predict that individual differences in a set of prosocial tendencies (i.e., spirituality, empathy, altruism, love of humanity) will be associated with individual differences in the frequency of perceived positivity resonance. Moreover, we hypothesize that this set of prosocial tendencies will motivate the adoption of COVID-19 health behaviors (i.e., handwashing, social distancing, mask wearing) that function to protect community health. Specifically, our *mediation hypothesis* states that individuals with higher (vs. lower) perceived positivity resonance will engage in more (vs. less) COVID-19 health behaviors and that this association can be explained by higher (vs. lower) prosocial tendencies. We tested this mediation hypothesis both cross-sectionally and prospectively across two online studies. Study 1 ($N = 1,059$) used the Day Reconstruction Method (DRM; Kahneman et al., 2004; Kahneman & Krueger, 2006) with university and national samples to obtain episode-level reports of people's social interactions and emotions throughout a typical day during the height of the initial US outbreak of COVID-19, when stay-at-home orders (i.e., lockdowns) were widespread (i.e., in April 2020). A subset of the national sample was assessed in two additional follow-ups at one month and three months following the initial assessment. Study 2 ($N = 227$) offered a conceptual replication with a community sample while also testing whether daily reports of pre-pandemic perceived positivity resonance (from March 2019 to November 2019) predicted pandemic-era prosocial tendencies and COVID-19 health behaviors.

4. Study 1

4.1 Method

4.1.1 Participants

Participants come from two samples: a University Sample (Sample 1) and a National Sample (Sample 2). Sample 1 participants were recruited between March 28th and April 30th, 2020 in exchange for course credit in psychology at either of two large public universities, one in California (CA) and the other in North Carolina (NC). During this time span, students at both universities had left campus and transitioned to remote learning due to the COVID-19 pandemic. To be eligible, students were over 18 and currently residing in the US. Initially, 595 students completed the survey. After removing participants who did not complete all study measures ($n = 56$), responses

from internationally-residing students ($n = 10$), participants who failed more than 1 of 3 attention checks ($n = 34$), and DRM responses that had too many overlapping episodes or repetitive, nonsensical episode names ($n = 11$), the final sample for analysis was $N = 484$ (68% women, Mean age = 20.5, $SD = 2.9$, range = 18-55 years, 71% students attending the university in CA). Most participants identified as either Asian (36%) or White or European American (34%), whereas 16 % identified as other, mixed, or preferred not to say, 11% identified as Hispanic or Latinx, and a small proportion identified as Black or African American (3%).

Sample 2 participants were recruited through Amazon's Mechanical Turk (MTurk) during the first week of April 2020 (April 1 - April 8th) for an initial assessment (Time 1; T1). Each user received $3 USD in exchange for participation. To be eligible, participants were over 18, fluent in English and residing in the US. Initially, 725 participants consented to complete the survey. After removing those who failed more than 1 of 3 attention checks ($n = 27$), 698 cases were assigned a personal id number. Further cases were removed if they had missing or nonsensical entries for the DRM ($n = 123$), resulting in a T1 analysis sample of $N = 575$ (50% female, Mean age = 36.7, $SD = 11.5$, range = 18-74 years). A majority of participants identified as White or European American (65%) with the next largest representation identifying as Black or African American (14%). Additionally, 8% identified as Asian, 4% as Hispanic or Latinx, and 8% identified as other, mixed or preferred not to say. While most participants were located anywhere in the US, CA ($n = 167$) and NC ($n = 151$) were over-sampled to support possible location-dependent comparisons to the University sample. For education, a majority of the National sample had a bachelor's degree (51%) or some college (25%), whereas 18% held a post-graduate degree. Five percent indicated that a high school diploma was their highest education.

Of the 575 Sample 2 participants in the T1 analysis sample, 307 returned for a follow-up survey approximately one month later (T2; April 29 – May 7, 2020), and 285 returned for a second follow-up approximately three months from the initial assessment (T3; June 24 – July 1, 2020). Returning respondents for T2 received an additional $1 USD in exchange for participation in a shorter survey. Among these, we excluded 7 participants for either failing more than one attention check and or having problems with their DRM responses: nonsensical text entries, no entries at all, or impossible or nonsensical time ranges, leaving a T2 sample of $N = 300$ ($n = 91$ CA, $n = 85$ NC; 54% female, Mean age = 39.2, $SD = 12.0$, range = 19-74 years). The second follow up at 3 months was available to anyone that completed the initial T1 assessment for an additional $3 USD. Two participants were excluded for failing 2 attention checks, leaving a T3 sample of $N = 283$ ($n = 87$ CA, $n = 68$ NC; 52% female,

Mean age = 38.7, SD = 11.9, range = 19-74). Aside from the returning sample being significantly older, no other

differences in demographic or primary variables of interest emerged between the sample that returned for T3 and

those who completed T1 (See Table S1 in the Electronic Supplemental Materials).

4.1.2 Materials and Procedures

We used the DRM to assess participants' social interaction and emotions. The DRM minimizes reporting

bias by cueing respondents to mentally visualize details of particular episodes in their day (e.g., "eating lunch,"

"phone call with sister"), rather than their general impression of themselves (Robinson & Clore, 2002). Participants

first reconstructed their previous day (i.e., "yesterday") by indicating what day of the week it was, then listing all

episodes from the time they woke up until they went to bed. Participants were asked to give each reported episode a

brief name, indicate its duration, and add any private notes to help recall their activities and experiences. After

identifying their full set of episodes, for each episode (cued by its brief name), participants were asked whether they

had been interacting with anyone for more than a few minutes, including by phone, text, email, or social media. For

episodes that included a social interaction, participants were asked to report the proportion of time within that

episode (from 0% to 100%) they had been interacting and their mode of interaction: *face-to-face*, *phone/video*

(digital synchronous), mediated communication (e.g., email, texting; digital asynchronous) and/or *not interacting.*

We then calculated the mean proportion of time spent in each mode of social interaction. Participants also indicated

who they were interacting with: *strangers/acquaintances, friend(s), family, romantic partner* and/or *coworker.*

Participants could select multiple responses to account for the possibility that a given episode included multiple

different social interaction types and/or partners.

For each social episode listed in the DRM, participants also reported on perceived positivity resonance (See

Table 1). To reduce participant burden, we used two of the original seven items from the Perceived Positivity

Resonance Scale (Major et al., 2018), selected to reflect the three key features of positivity resonance (i.e., co-

experienced positivity, care, and synchrony). In a previous study that also assessed perceived positivity resonance at

the episode level (i.e., initial assessments of Study 2), this two-item scale demonstrated high correlation with the full

7-item scale (r = .97, Zhou et al., revision invited We computed the mean of these two items per episode to create

episode-level perceived positivity resonance scores. To create a person-level index, we computed the mean, within

individuals, across all episode-level scores (social episodes only). For each episode (social and nonsocial),

participants separately reported the greatest amount that they experienced any positive or negative emotion using a

5-point Likert-type scale ranging from 1 (not at all) to 5 (extremely). To create person-level indices, we computed

mean positive and negative emotion scores, within individuals, across all episodes reported for the day. For the

episodes in which participants reported interacting with others face-to-face for some proportion of time, they were

asked "During this episode, how concerned were you that your activities could increase your risk of contracting or

spreading the novel coronavirus," using a response scale of 1 (not concerned at all) to 7 (extremely concerned).

Person level-indices were created by computing the mean within individuals across all episodes for the day.

Prosocial tendencies were assessed at the individual level. Table 1 displays sample items and alpha ranges

for both samples and all time points for all primary study measures. Participants responded to two items selected to

assess both enacted and experienced spirituality (based on Underwood & Teresi, 2002, also used in Study 2).To

assess both emotional and cognitive empathy, participants completed the Empathic Concern and Perspective Taking

subscales of the Brief Form of the Interpersonal Reactivity Index (B–IRI; Ingoglia, et al., 2016). For altruism

assessment, participants responded to two items selected to assess both enacted and experienced altruism (based on

Rushton et al., 1981, also used in Study 2). For Love of Humanity, items were selected from an unpublished

"Different Kinds of Love" scale (Campos et al., 2002).

The initial assessment (Sample 1 and T1 of Sample 2) featured only a few single-item measures of COVID-

19 health behaviors, whereas the 1- and 3-month follow-up assessments (T2 and T3; Sample 2 only) included more

fine-grained behavioral measures adapted from NSF-funded work by Michelle Shiota (Shiota, 2020).[1] Table 1

displays health behavior items for all time points. For social distancing behavior, at T1, three 1-item measures were

used to separately assess perceived social distancing effort, social distancing importance, and social contact outside

the home. At T2 and T3, the measure of social-distancing behaviors consisted of 5 items, again adapted from Shiota

(2020), which were averaged for a composite social distancing score. To test the construct validity of our latent

factor of prosocial tendencies, we also assessed COVID-19 related charitable behavior. Specifically, the following

one-item question was used at T2: "There are many different ways to help others since the COVID-19 outbreak.

Since the outbreak began in your area, have you engaged in any charitable behaviors? Below is an example of

behaviors that are considered charitable: Gave money to someone in economic need, or to an organization. Gave

another person food or household supplies they needed. Donated medical supplies such as masks and gloves.

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[1] At the time of the initial assessment, face coverings had not been encouraged. The US CDC changed their
recommended guidelines on mask-wearing on April 3rd, 2020. Therefore, our second assessment included mask-
wearing, as well as other more detailed measures of hygiene practices.

Contacted a person you know who may be lonely, to offer support. Helped another person with errands, such as

groceries or prescriptions. Provided caregiving for someone outside your household who is sick. Volunteered with

an organization providing coronavirus-related assistance." Participants responded from 0 = never, to 3 = 3 or more

times). This item was also adapted Shiota (2020).

We included additional items to serve as covariates. Political orientation was indexed as the mean of two

items that captured both economic and social dimensions of political orientation (Carmines & D'Amico, 2015):

"When it comes to social issues, I am…" and "When it comes to economic issues, I am…" on a scale from 1 ("very

liberal") to 7 ("very conservative"), with a midpoint of 4 ("moderate" ; Sample 1 Alpha = .84; Sample 2 Alpha =

.93). General concern for the self was measured with one item "I am concerned about COVID-19 because of the

potential consequences (health or otherwise) for myself" on a scale of 1 (not concerned) to 7 (most concerning). We

also assessed whether the participant or someone they live with was considered high-risk for severe illness from

COVID-19 based on the CDC guidelines at time of data collection. These guidelines were presented to participants

(see ESM S8 for full prompt), followed by the questions: "Are you or someone you live with considered high risk?"

Participants could then check a box indicating themself, someone they live with, or neither apply to me. Participants

were also asked if they had been tested for COVID-19 with a yes or no response, and if they had been diagnosed

with COVID-19 with a yes or no response. Additionally, participants were presented with a 13-item illness

symptoms checklist (Elliot & Sheldon, 1998) and were asked how often they had experienced each symptom during

the past week, from 1 = not at all to 8 = very frequently. Illness symptoms were indexed by the mean of the 13 items

(Sample 1Alpha = .86; Sample 2 Alpha = .96).

4.1.3 Analytical Approach

Preliminary analyses were conducted to obtain descriptive statistics and zero-order correlations among

study variables. Next, a series of multi-group structural equation models (SEM) were conducted to test the

hypothesized model across the populations represented by Sample 1[2] and Sample 2 (Kline, 2015). The SEMs were

fit in R with the package Lavaan (Rosseel, 2012), with parameter estimates obtained with full information maximum

likelihood estimator and unbiased errors obtained via bootstrapping with 1000 resamples (Nevitt & Hancock, 2001).

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[2] In preliminary analyses with the University Sample, a multi-group CFA measurement model and a multi-group
SEM path model for the two University groups (CA and NC) demonstrated that the association among key variables
of interest did not significantly differ across the two universities (see Table S2 in the ESM). We thus combined
participants from the two universities into one sample.

The statistical significance of effect estimates was evaluated based on asymmetrical bootstrapped 95% CIs (Bollen & Stine, 1990), although for reference we also report *p*-values, which correspond to the z-statistic under a standard normal distribution. Analyses occurred in two phases:

In phase one, we tested a measurement model to index prosocial tendencies as a latent variable using confirmatory factor analysis (CFA), specifically, multi-group CFA (Kline, 2015) with Samples 1 and 2 treated as separate groups. We hypothesized that a latent variable that indexed prosocial tendencies would emerge from the following four indicators: spirituality, empathy, altruism, and love of humanity (Figure 1). All indicators were set to load on one latent factor (i.e., prosocial tendencies). Measurement invariance was investigated across the two samples. Because we were only interested in comparing covariation patterns across samples, we only aimed to establish metric invariance, that is, that each indicator contributed to the latent factor to a similar degree across the two samples.

In phase two, we integrated the hypothesized measurement model into the hypothesized path model (see Figure 2). A direct path and an indirect path through prosocial tendencies from perceived positivity resonance to COVID-19 health behaviors were estimated. Integrating follow-up data from T2 and T3, we modeled the prospective mediational relationships among perceived positivity resonance, latent prosocial tendencies, and COVID-19 health behavior. To do so, we ran a separate path model with T1 positivity resonance as the predictor, T2 prosocial tendencies as the mediator, and T3 COVID-19 health behaviors as the outcome dependent variables.

For each of these phases, model specification, estimation, and selection were conducted in a stepwise manner. The initial models allowed all parameters to be freely estimated for each of the two samples. To acquire the best fitting and most parsimonious model, equality constraints were applied to the factor loadings and intercepts in the measurement model, with regression coefficients in path models and model fit statistics compared to the initial unrestricted model using likelihood ratio tests (Kline, 2015). Restrictions that did not significantly reduce model fit were retained. The final model fit was comprehensively evaluated using a combination of fit indicators including the comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). Conventional cut-offs for fit indices were used as a reference for judging models: CFI values greater than .95, RMSEA values less than .08, and SRMR values less than .08 indicate good model fit (Schreiber et al., 2006).

In several secondary analyses, we tested alternatives to the hypothesized effects. Specifically, we reversed the implied direction of causal inference by positioning prosocial tendencies as the predictor and positivity resonance as the mediator in the mediation model. We also tested whether positivity resonance and prosocial tendencies have effects on *shifts* in COVID-19 behaviors across time. To do so, we set the outcome dependent variables as residual change scores for health behaviors, obtained by predicting T3 behaviors controlling for T2 behaviors.

In subsequent sensitivity analyses, control covariates were added to the main models, including competing predictors of prosocial tendencies (i.e., positive emotions, negative emotions, and frequency of social episodes) and competing predictors of COVID-19 health behaviors (i.e., positive emotions, negative emotions, political orientation, COVID-19 self-concern, ethnicity, gender, age, education, illness symptoms, being considered high-risk for COVID-19, living with someone who is considered high-risk, tested for COVID-19, and diagnosed with COVID-19). To avoid overfitting with the large number of covariates, we followed the one parameter for every ten observations rule (Harrell et al., 1996) and kept the numbers of parameters less than or equal to 101 for cross-sectional models and 27 for prospective models. To do so, we separately tested two sets of covariates: (1) emotional and social covariates (positive emotions, negative emotions, and frequency of social episodes) and (2) demographic and COVID-19-related covariates (political orientation, COVID-19 self-concern, ethnicity, gender, age, education, illness symptoms, being considered high-risk for COVID-19, living with someone who is considered high-risk, tested for COVID-19, and diagnosed with COVID-19), as well as examined each behavioral outcome separately in models that contained the second set.

4.2 Results

4.2.1 Preliminary Analyses

A total of 10,728 episodes were reported through the DRM. Specifically, Sample 1 reported a total of 4,482 episodes, with each participant reporting an average of 9.3 episodes (range = 2-29 episodes). Sample 2 reported a total of 6,246 episodes at T1, with each participant reporting an average of 10.9 episodes (range = 1-30 episodes).

Of these 10,728 total episodes, 5,286 were identified as involving a social interaction. Specifically, in Sample 1, 58% of episodes (2,611) were social, with each participant reporting an average 5.4 episodes that included an interaction (range = 0-20 episodes). Of the 484 participants, 37 reported having only social episodes, 2 reported having only non-social episodes and 20 reported only one social episode. In Sample 2, 43% of episodes (2,675) were

social, with each participant reporting an average of 4.7 episodes that included an interaction (range = 0-30 episodes). Of the 575 participants, 28 reported having only social episodes, 39 reported having only non-social episodes, and 51 reported only one social episode.

Table 2 reports descriptive statistics for social interactions, perceived positivity resonance, and concern of spreading or contracting virus broken down by interaction partner and mode of communication for Samples 1 and 2. Across the two samples, people reported that they spent most of their social time in face-to-face interactions, followed by digital synchronous or asynchronous interactions, and that most social partners were family and romantic partners, followed by friends, co-worker/classmates, and then strangers. Consistent with previous research (Major et al., 2018), perceived positivity resonance was highest for face-to-face interactions. Participants also felt more frequent positivity resonance and were less concerned about contracting COVID-19 with romantic partners and family, followed by friends, co-workers, and strangers.

Table 3 and 4 shows the means, standard deviations, and zero-order correlations among main study variables and covariates. Partially consistent with the primary hypothesis, at T1, prosocial tendencies were correlated with the 1-item assessments of handwashing, perceived importance of social distancing, and effort expended on social distancing, but not the number of days being in proximity with others outside one's home. For Sample 2, T1 and T2 prosocial tendencies were also associated with T2 & T3 composite hygienic behaviors, but not T2 & T3 composite social distancing behaviors.

Demographic and COVID-19 related factors were also associated with COVID-19-health behaviors, and thus these factors were included in sensitivity analyses as control variables. At T1, one participant in Sample 1 was diagnosed with COVID-19, among five who had been tested. In Sample 2, also at T1, ten participants were diagnosed with COVID-19 out of 27 who had been tested. Cumulatively, in Sample 2, fifteen had been diagnosed with COVID-19 out of 79 tested across T1 through T3.

4.2.2 Multi-group Measurement Model of Prosocial Tendencies

Table 5 reports the fit information of multi-group latent measurement models with four indicators: spirituality, empathy, altruism, and love of humanity and multi-group mediation models. The measurement model achieved our aim of metric invariance, i.e. invariance in factor loadings of indicators on latent prosocial tendencies across the two samples. We note that scalar invariance was not achieved, i.e. the mean level of these indicators were not equal across the two samples. Yet because we were only interested in comparing covariation patterns across

samples, metric invariance was sufficient. The metric invariance model demonstrated good fit (χ^2(7) = 29.382, $p <$

.001, CFI = .979, RMSEA = .078, SRMR = .029; Table 5), and all indicators loaded significantly (ps < .05) on latent

prosocial tendencies (Figure 1). Thus, we continued to incorporate the hypothesized latent factor for prosocial

tendencies in subsequent path models.

As empathy was omitted by error from the T2 survey, we fit a separate measurement model with three

indicators for T1 and T2 prosocial tendencies and exported the factor scores for all latent measurement models.

Table S3 in the ESM shows the means, standard deviations, and correlations between factor scores and charitable

behaviors. The factor scores for a 4-indicator factor of T1 prosocial tendencies were extremely highly correlated

with the 3-indicator factor of T1 prosocial tendencies (r = .95) and highly correlated with the 3-indicator factor for

T2 prosocial tendencies (r = .74), the latter of which is on par with a good test-retest reliability threshold (Cicchetti,

1994). We thus consider the 3-indicator and 4-indicator latent measures of prosocial tendencies to be roughly

equivalent. Next, we tested the construct validity of T1 and T2 latent factors of prosocial tendencies by correlating

them with T2 and T3 COVID-19-related charitable behaviors. All associations were positive and statistically

significant (r = .24-.33, Table S3), thereby supporting the validity of the latent factor measurement.

4.2.2 Cross-sectional Effects of Positivity Resonance on Time 1 COVID-19-related Behaviors

To select the best fitting multi-group model, we first fit a model that freely estimated the regression paths

for each sample, before constraining these regression paths to the same value across samples. The constrained model

showed a significant decrease in fit compared to the free model ($\Delta\chi^2$(9) = 22.384, p = 008; Table 5). According to

the parameter estimates in the free model, prosocial tendencies significantly predicted social distancing effort in

Sample 2 (National), but not in Sample 1 (University). Therefore, we allowed the paths between prosocial

tendencies and social distancing effort to be different in a subsequent, partially constrained model. This model has

similar fit to the free model ($\Delta\chi^2$(8) = 12.769, p = .120 (Table 5). As the partially constrained model also showed

good overall fit (χ^2(45) = 112.501, $p <$ .001, CFI = .962, RMSEA = .054, SRMR = .040), we moved forward with it.

Figure 2 shows the path diagram for this model. As hypothesized, aggregated perceived positivity resonance during

social episodes predicted greater prosocial tendencies (b = .108, 95% CI = [.86,.131], $\beta_{Sample\ 1}$ = .381, $\beta_{Sample\ 2}$ = .349,

$p <$ .001). Prosocial tendencies in turn predicted greater handwashing (b = .282, 95% CI = [.146,.440], $\beta_{Sample\ 1}$ =

.153, $\beta_{Sample\ 2}$ = .188, $p <$ .001), and through prosocial tendencies, positivity resonance had a significant indirect

effect on handwashing (indirect effect: b =.030, 95% CI = [.015,.049], β = .066, p = .001; total effect: b =.054, 95%

CI = [.026,.089], β = .116, p = .001). After controlling for the mediator (i.e., prosocial tendencies), positivity

resonance no longer had a direct effect on handwashing (p = .175), suggesting complete mediation. The same

complete mediation pattern was found for the perceived importance of social distancing: Effect of prosocial

tendencies: b = .275, 95% CI = [.158, .399], $β_{Sample\ 1}$ = .167, $β_{Sample\ 2}$ = .222, p < .001; indirect effect of positivity

resonance: b = .030, 95% CI = [.017.044], β = .077, p < .001; total effect: b =.043, 95% CI = [.016,.069], β = .111, p

= .001. For perceived social distancing effort, this complete mediation pattern was significant only in the National

Sample (effect of prosocial tendencies: b =.267, 95% CI = [0.159, 0.397], β = .248, p < .001; indirect effect: b

=.029, 95% CI = [.017,.046], β = .087, p < .001), whereas no significant effects on social distancing effort emerged

in the University sample (ps ≥ .150). Days spent in proximity to people outside home, however, was neither

predicted by prosocial tendencies nor by positivity resonance (ps >.185).

4.2.3 Prospective Effects of Positivity Resonance on COVID-19-related Behaviors

In a separate model, we examined the effects of positivity resonance on future COVID-19 health behaviors

through prosocial tendencies (Sample 2 only). Figure 3 shows the path diagram for this model. The model showed

excellent overall fit ($χ^2(6)$ = 7.122, p = .310, CFI = .994, RMSEA = .026, SRMR = .027). T1 positivity resonance

predicted T2 prosocial tendencies (b = 0.128, 95% CI = [.058,.196], β = .338, p < .001), which in turn predicted T3

hygienic behaviors (b = .305, 95% CI = [.134,.508], β = .437, p = .002). T1 positivity resonance also had an indirect

effect mediated by T2 prosocial tendencies on T3 hygienic behaviors (indirect effect: b = .039, 95% CI =

[.016,.080], β = .148, p = .011; total effect: b = .056, 95% CI = [.023,.093], β = .212, p = .002), and no direct effect

after controlling for the mediator (p = .416), suggesting full mediation.

This mediational pattern was not significant for T3 social distancing: Effect of prosocial tendencies: b = -

.052, 95% CI = [-.171,.062], β = -.078, p =.392.; indirect effect: b =-.007, 95% CI = [-.026,.007], β = -.026, p =

.405; total effect: b = -.011, 95% CI = [-.038,.023], β = -.045, p = .452. Whereas the link between prosocial

tendencies and social distancing effort and behaviors were mixed in the previous cross-sectional analyses, the

prospective findings for the National Sample suggests that prosocial tendencies were unrelated to these behaviors.

Secondary Analyses

In secondary analyses, we first tested alternative mediation models, for both the cross-sectional and

prospective analyses, in which positivity resonance was positioned as the mediator that links prosocial tendencies, as

predictor, to the outcomes of health behaviors. No significant indirect effects of prosocial tendencies through

positivity resonance emerged in these alternative models (see Table S4 in the ESM). Second, we also tested the

indirect effect of positivity resonance through prosocial tendencies on shifts in health behaviors, which were

operationalized as residual changes in outcome behaviors (i.e. each of T3 behaviors was regressed on their

respective T2 behaviors). This model revealed that prosocial tendencies significantly predicted shifts in hygienic

behaviors (b =.205, 95% CI = [.036, 0.383], β = .234, p = .019). Positivity resonance also had a significant total

effect on shifts in hygienic behaviors (b = .031, 95% CI = [.004, 0.064], β = .123, p =.040), which was completely

mediated by prosocial tendencies (indirect effect: b = .019, 95% CI = [.003,.048], β = .076, p = .090; direct effect: b

=.012, 95% CI = [-.021,.046], β = .046, p = .488). No significant effects emerged regarding shifts in social

distancing behaviors (ps > .214).

To test whether positivity resonance predicted prosocial tendencies independently of experienced emotions

and quantity of social interaction, we regressed prosocial tendencies on positive and negative emotions, and

interaction frequency (number of social episodes); we also regressed behavioral outcomes on positive and negative

emotions. The significant pattern of cross-sectional and prospective findings remained mostly unchanged after

controlling for these covariates (see Table S5 in the ESM). The one exception was that for the University Sample,

the cross-sectional indirect link between positivity resonance and perceived social distancing effort through

prosocial tendencies became significant after the covariates were introduced (effect of prosocial tendencies: b =.132,

95% CI = [.025, .258], β = .133, p = .026, indirect effect: b =.010, 95% CI = [.002,.020], β = .032, p = .031).

In separate models, we tested the effects of prosocial tendencies and indirect effects of positivity resonance

on individual COVID-19-related behaviors while controlling for demographic and COVID-19 related covariates

(i.e., age, gender, ethnicity, political orientation, education, illness symptoms, being considered high-risk for

COVID-19, living with someone who is considered high-risk, tested for COVID-19, and diagnosed with COVID-

19). For cross-sectional models, we controlled for T1 test and diagnosis status, whereas for prospective models, we

controlled for cumulative test and diagnosis status. After taking into account these factors, the pattern of cross-

sectional and prospective findings did not meaningfully change (see Table S6 in the ESM).

4.2.4 Strength and Limitations of Empirical Approach

One strength of Study 1 is the latent variable approach to assess the broad construct of prosocial tendencies.

This approach reduced the impact of low reliability in the measures of any single indicator variables. A second

strength is the use of the DRM, which assessed experiences aggregated across all episodes on a typical day for each

respondent during the early stages of the pandemic. A third strength is the use of COVID-19 health behavior

measures across multiple time points, which allowed us to examine cross-sectional and prospective effects on

behaviors as well as effects on behavior shifts. One limitation of Study 1 is that it measured positivity resonance at a

time when most in the US were under stay-at-home orders, which likely altered the quantity, quality, and modes of

respondents' typical social interactions, perhaps differently so across individuals. This approach does not capture

how people interact during non-pandemic times, and may have restricted the range of people's social and emotional

experiences. We undertook Study 2 both to conceptually replicate the findings of Study 1 and to address this

limitation using data collected prior to the COVID-19 pandemic. In Study 2, people's day-to-day social connections

were assessed in 2019. Our primary aim was to examine how participants' characteristic levels of positivity

resonance, pre-pandemic, prospectively predicted their prosocial tendencies during the 2020 pandemic and,

indirectly, their COVID-19 health behaviors.

5. Study 2

5.1 Method

5.1.1 Participants

　　　　Participants ($N = 405$) from an initial 2019 NC community-based daily diary study (that included

randomization to one of 4 study conditions) were recontacted via email and asked to participate in a week-long

follow-up assessment in April 2020, while under state-issued stay-at-home orders, with the opportunity to earn a $25

gift card. All who consented were used in the analysis ($N = 227$; 82% female, Mean age = 34.5, $SD = 11.4$, range =

20-64 years). In this follow-up sample, 71% identified as White, 12% as Black or African American, 8% as Asian

and 6% Hispanic. A large portion of the sample had a bachelor's degree (42%) or a master's degree (33%), and 11%

had a professional or doctoral degree, 4% an associate's degree, 7% some college, and 2% a high school degree or

less. The returning participants did not differ from the non-returning ones in demographic variables, condition

assignment, or perceived positivity resonance (see Table S7 in ESM)

5.1.2 Materials and Procedures

　　　　The community sample had previously participated, on a rolling basis, in a 5-week social connection study

between March and November of 2019. The primary objective of that pre-registered study was to test whether

positivity resonance can increase prosocial tendencies (results reported in Zhou et al., revision invited), and

participants were randomized into experimental and control conditions accordingly. Participants had completed,

over five weeks, nightly reports on their emotions, select social interactions, and prosocial tendencies, both enacted

and experienced. To minimize the impact of experimental condition and maximize the sample size, the current

Study 2 drew from each participant's first week of nightly reports during their 2019 study involvement.[3] Between

April 28th and May 11th, 2020, follow-up participants completed nightly surveys for 7 days to assess perceived

positivity resonance during social interactions (with close vs. distal others, assessed separately) and two prosocial

tendencies (spirituality and altruism). Daily items were averaged for the week for analyses. COVID-19 health

behaviors and one prosocial tendency (love of humanity) were reported once in reference to the past week after the

7-day reporting period (see Table 1). Prosocial tendencies were assessed with the same scales as used in Study 1,

except we inadvertently did not measure empathy in Study 2. Charitable COVID-19 behaviors (1 item) was also

measured the same way as Study 1 to validate the prosocial latent factor in this independent sample.

Pre-pandemic positivity resonance was assessed by aggregating the first seven days of nightly reports from

the 2019 study (See Table 1). Each evening (after 6 p.m. local time), participants were asked: "Think back to the

single longest interaction you had with one or more close others [strangers or acquaintances] today. Take a moment

to recall and mentally relive this event, including how the event unfolded, what time of day it was, and what it was

like." Next, positivity resonance was captured using the full 7-item Perceived Positivity Resonance Scale for each

target (Major et al., 2018). For the current study, both targets (close and distal) were averaged together for a total

perceived positivity resonance score. Pandemic-era positivity resonance was assessed daily using this same 7-item

measure across the seven days of the follow-up survey.

Besides aforementioned demographic factors, we also include pre-pandemic daily positive and negative

emotion in the sensitivity analysis model as controls. Pre-pandemic daily emotions were assessed by aggregating the

same first seven days of nightly reports from the 2019 study that were used to index pre-pandemic positivity

resonance. Emotions were assessed using the same daily 1-item measures (one for positive and one for negative

emotion) as in Study 1. We measured political orientation on day 7 (i.e., the final day of the follow-up assessment in

2020) using the same two items as used in Study 1 ($\alpha = .85$). Same as Study 1, participants reported if they or

someone they lived with was considered high-risk for COVID-19 and if they had been tested or diagnosed with

COVID-19 (five people were tested but no one was diagnosed as positive in this sample). Illness symptoms were

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[3] The focus of the current Study 2 is not on the effects of randomized conditions. Even so, condition served as a control variable in sensitivity analyses. The experimental manipulation occurred during the first week of nightly reports.

indexed by a single item "Today I felt physically unwell or under the weather" (1 = not at all to 5 = extremely), which was completed daily and averaged for the same follow-up week as reporting on pandemic-era positivity resonance, prosocial tendencies, and health behaviors.

5.1.3 Analytical approach

Similar to Study 1, descriptive statistics and zero-order correlations among the study variables were computed in preliminary analyses. Next, we used SEM to test path models using the same estimation approach and software. A common latent factor of prosocial tendencies was extracted from the three available indicators (spirituality, altruism, and love of humanity) using CFA. As this measurement model was fully saturated with three indicators, we could not evaluate fit prior to including it in the structural model. We then estimated a direct path and an indirect path through prosocial tendencies from positivity resonance (measured pre-pandemic and during the pandemic) to COVID-19-related behaviors (Figure 4). A bias-corrected bootstrapping procedure (1000 resamples) was used to obtain 95% confidence interval.

In sensitivity analyses, to control for differences in time of pre-pandemic positivity resonance assessments, we added an interaction term to the path model, crossing perceived positivity resonance with the number of days passed between the last assessment in 2019 and the follow-up survey in 2020. Control covariates were also added to the path analysis, including competing predictors of prosocial tendencies (experimental condition, positive emotions, negative emotions)[4] and competing predictors of COVID-19-related behavior (experimental condition, positive emotions, negative emotions, political orientation, feeling under the weather, being considered high-risk for COVID-19, living with someone who is considered high-risk, and tested for COVID-19). To avoid overfitting, we followed the one parameter for every ten observations rule (Harrell et al., 1996) and kept the numbers of parameters less than or equal to 22. To do so, we tested two sets of covariates separately: (1) experimental conditions and emotion covariates, and (2) demographic and COVID-19-related covariates (political orientation, ethnicity, gender, age, education, feeling under the weather, being considered high-risk for COVID-19, living with someone who is considered high-risk, and tested for COVID-19), while examining each behavioral outcome in separate models. We assessed model fit similarly to Study 1, using a combination of fit indicators (CFI, RMSEA, and SRMR).

5.2 Results

5.2.1 Preliminary analyses

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[4] Quantity of social interaction was assessed in Study 1 but not Study 2.

Table 6 shows the means, standard deviations, and zero-order correlations among included variables. Partially consistent with the primary hypotheses, latent prosocial tendencies were associated with hygienic behaviors. Associations between demographic variables and COVID-19-related behavior also emerged, and therefore these variables were controlled in sensitivity analyses. Perceived positivity resonance slightly increased from the pre-pandemic to pandemic era, $t(226) = 2.94$, $p = .004$, $d = .20$.

Replicating findings of Study 1, the latent factor of prosocial tendencies was associated with charitable behaviors ($r = .29$, $p < .01$), providing evidence for the construct validity of our latent factor measure.

5.2.2 Cross-sectional Effects of Pandemic-era Positivity Resonance on COVID-19-related Behaviors

Figure 4 shows the model results for both pre-pandemic and pandemic-era positivity resonance. The cross-sectional model using pandemic-era positivity resonance shows excellent fit, $\chi^2(6) = 7.371$, $p = .288$, CFI = .993, RSMEA = .032, SRMR = .023, and the overall pattern of significant findings replicated those from Study 1 (Figure 4). Because pandemic-era positivity resonance was measured around the same time as prosocial tendencies, we also tested an alternative mediation model in which prosocial tendencies is positioned as the predictor and positivity resonance as the mediator. Similar to Study 1, positivity resonance did not mediate the association between prosocial tendencies and health behaviors (see Table S4 in the ESM).

5.2.3 Prospective Effects of Pre-pandemic Positivity Resonance on COVID-19-related Behaviors

The hypothesized longitudinal mediation model for pre-pandemic positivity resonance (Figure 4) showed excellent fit, $\chi^2(7) = 3.852$, $p = .797$, CFI = 1.000, RSMEA = .000. Pre-pandemic positivity resonance predicted greater pandemic-era prosocial tendencies ($b = .166$, 95% CI = [.099,.271], $\beta = .501$, $p < .001$), and through prosocial tendencies, indirectly predicted more frequent hygienic behaviors (effect of prosocial tendencies: $b = .298$, 95% CI = [0.098, 0.585], $\beta = .258$, $p = .009$; indirect effect of positivity resonance: $b = .050$, 95% CI = [.019, .093], $\beta = .129$, $p = .008$). The direct effect of positivity resonance was nonsignificant after controlling for prosocial tendencies, suggesting complete meditation ($b = 0.014$, 95% CI = [-.037, .061], $\beta = .035$, $p = 0.595$). Similar to Study 1, social-distancing behaviors were neither related to prosocial tendencies ($b = .002$, 95% CI = [-.185, .174], $\beta = .002$, $p = .980$) nor predicted by pre-pandemic positivity resonance (direct effect: $b = .014$, 95% CI = [-.037,.061], $\beta = .043$, $p = .595$, indirect effect $b = .000$, 95% CI = [-.030, .032], $\beta = .001$, $p = .980$, total effect: $b = .014$, 95% CI = [-.023,.048], $\beta = .037$, $p = .439$).

5.2.3 Sensitivity Analyses

We tested whether the effect of pre-pandemic positivity resonance on pandemic-era prosocial tendencies differed by how much time had passed between the pre-pandemic assessment and the follow up COVID-19-related survey. The interaction effect was not significant (b = .000, SE = .001, 95% CI = [-.001,.002], p = .938). Experimental condition also did not influence pre-pandemic positivity resonance, assessed during Week 1 of the intervention, $F(3,223)$ = 1.396, p = .245, nor pandemic-era positivity resonance, $F(3,223)$ = 1.398, p = 0.244.

To test whether pre-pandemic positivity resonance predicted prosocial tendencies independent of other factors, we regressed prosocial tendencies on positive emotions, negative emotions, and experimental conditions. In predicting COVID-19-related health behaviors, we also controlled for experimental condition. Introducing these covariates did not change the patterns of findings for hygienic behaviors and social distancing behaviors (see Table S8 in the ESM).

Separately, we tested whether the effects of positivity resonance and prosocial tendencies on COVID-19 health behaviors remain after controlling for demographic and COVID-19-related covariates (age, gender, ethnicity, political orientation, education, being considered high-risk, living with someone considered high-risk, and tested for COVID-19). After covariates were introduced, the pattern of results remained the same for hygienic behaviors and social distancing behaviors (See Table S9 in the ESM). Thus, as for Study 1, the indirect effect of positivity resonance on COVID-19 health behavior emerged prospectively and was independent from any effects of positive or negative emotions or experimental conditions, or effects of demographic and COVID-19-related factors.

5.2.4 Strength and Limitations of Empirical Approach

Study 2 overcame a key limitation of Study 1 by assessing perceived positivity resonance in 2019, prior to the onset of the COVID-19 pandemic. Moreover, we measured perceived positivity resonance in Study 2 with the full 7-item scale (Major et al., 2018), across two categories of social partners (close vs. distal others), each evening for a week. This assessment of positivity resonance should thus be more stable against day-to-day fluctuations and unaffected by the substantial changes in people's social opportunities created by stay-at-home mandates. These differences in assessment strategy increase the generalizability of the conceptual replication offered by Study 2.

6. Discussion

Evidence from two studies (total N = 1,286) support the hypothesis drawn from the Positivity Resonance Theory of co-experienced positive affect, that social interactions marked by mutual warmth, concern, and synchrony are associated, both cross-sectionally and prospectively, with reported pandemic-era health behaviors that can curb

viral spread (i.e., washing hands and wearing masks). For an illustration, in the National Sample of Study 1, among people who scored in the top 20% on positivity resonance, 87% reported "almost always or always" practicing hygienic behaviors, such as handwashing and mask wearing, whereas among the bottom 20%, only 56% reported doing the same. Furthermore, both studies suggest that the pathway between positivity resonance and COVID-19 health behavior is indirect, as hypothesized, accounted for by the higher levels of prosocial tendencies associated with more frequent experiences of positivity resonance. Additionally, our latent measure of prosocial tendencies in both studies was predictive of reporting more COVID-19-related charitable acts, providing validity for this mediating construct. While the present study focuses on individual differences rather than behavioral adoption, limited evidence also emerged in Study 1 that these effects grew stronger over time. Specifically, positivity resonance predicted significant increases in COVID-19 health behaviors across time points, indirectly through prosocial tendencies, providing ample avenues for future research on effective public health interventions.

Empirical support for the behavior of social distancing was mixed. In Study 1, for both samples, perceived positivity resonance indirectly predicted the importance people reported placing on social distancing. The effort they reported putting into social distancing, however, was only predicted (indirectly) by positivity resonance in the National sample, and then only cross-sectionally using a 1-item index, and not longitudinally, using a composite index. Additionally, no effects for the composite index of social distancing emerged in Study 2.

Evidence for mediation through prosocial tendencies remained significant after accounting for other competing predictors of prosocial tendencies and health behaviors. In regards to competing predictors of prosocial tendencies, the association between positivity resonance and COVID-19 health behaviors held after accounting for overall positive and negative affect and the quantity of social interactions, supporting the Positivity Resonance Theory that the individual components alone (i.e., positive affect, social interaction) are necessary but not sufficient for experiencing positivity resonance. Thus, positivity resonance appears to be a distinct and robust motivator of prosocial tendencies. The affective quality of one's social relationships, then, may protect not only the health and well-being of individuals (Prinzing, et al., in press; Major et al., 2018), but also that of the community members these individuals encounter. In regards to competing predictors of engaging in COVID-19 health behaviors, the association further remained after accounting for demographics, such as age and political orientation, as well as COVID-19-related factors such as whether the participant or someone they lived with was considered high-risk for severe illness from COVID-19 and if they had experienced illness symptoms in the last week. This suggests that

motivation to engage in health-protective behaviors for the self and community are driven by prosocial, other-oriented concern developed through high-quality social connection, rather than individual threats to health or political ideology.

A strength of the present research is the robustness of findings across different samples and measurement methods, in both cross-sectional and prospective designs. In both studies, we used a latent variable approach to assess prosocial tendencies, which mitigated against the low measurement reliability of any individual indicator. In Study 1, perceived positivity resonance was measured with 2-items in more than 5,000 reported social episodes using the DRM, a less-biased method compared to traditional self-reports (Kahneman & Krueger, 2006). In Study 2, pre-pandemic positivity resonance was measured with 7-items across 7-days, allowing for a marker stable against day-to-day fluctuations in environments and routine, one captured during a time of 'normal' social life. Notably, perceived positivity resonance increased slightly ($d = .20$) in the early stage of the pandemic, relative to 2019, indicating that some individuals may have benefited socially (e.g. by spending more quality time with loved ones) during the initial lock-down. Together, our studies demonstrate a robust and generalizable effect of positivity resonance on prosocial tendencies, extending to COVID-19 health behaviors.

Positivity Resonance Theory holds that accumulated moments of co-experienced positive affect build personal and social resources (i.e., prosocial tendencies). Although the present studies cannot provide causal support for this assertion, via the separation (across assessment periods) of our psychological variables and COVID-19 health behaviors, these studies do establish temporal precedence consistent with this theory-derived causal direction. We suspect, however, that the reverse causal direction is also at play. That is, prosocial tendencies are likely to be a vantage resource in that their presence serves to amplify subsequent experiences of (co-experienced) positive affect, reflecting the reciprocal causality indicative of upward spiral dynamics (Van Cappellen et al., 2019). Another limitation is our exclusive reliance on self-report measures. Although we sought to minimize biases associated with self-reports by using the DRM, this method can be taxing to participants. Additionally, even though our use of a latent measure of prosocial tendencies is a strength, any composite measure is necessarily limited by the set of indicators chosen. One limitation of our selected set of indicators is the lack of standardization in temporal focus (see Table 1). Also, while under 'stay-at-home' orders, many days may blend together, potentially making it difficult for participants to recall particular features of the previous day. Future studies might incorporate ecological momentary assessments to capture details of social interactions multiple times within the same day, an approach that

may further reduce reporting bias and be less burdensome. While objective measures of positivity resonance such as behavioral (Otero et al., 2019) or physiological indicators (Chen et al., 2020) exist, they are less feasible to collect during a pandemic.

Finally, we did not find strong support for the behavior of social distancing. This may be due to variation across the country in government mandates and degree of viral spread. Alternatively, our measurement approach did not account for people who may have formed "social bubbles"—i.e., repeated contact with the same few people outside the home—which is thought to be a safe and effective way to mitigate spread (Block et al., 2020). Furthermore, while items such as dining out were of great concern early in the pandemic (i.e., April 2020), by T3 (late June 2020) when the final follow-up assessment for Study 1 was conducted, many businesses had adapted by expanding outdoor dining, installing plexiglass or controlling the flow of customers. Thus, some of our social distancing items may not have provided stable reflections of people's effort or consideration of physical distancing. Finally, social distancing is a more complex health behavior (compared to handwashing) in that it may not entirely be in one's control to remain 6 feet away in public settings (e.g., in a store aisle with unpredictable passersby). To the extent that respondents' behavioral intentions did not align with reality, our measure may have misrepresented an individual's motives or concern for others. In sum, our measurement of social distancing in the present study likely posed a limitation.

Conclusion

Together, two studies offer the first evidence that the affective quality of people's ordinary social interactions in both private and public spaces may shape the enactment of infection-reducing behaviors. These studies contribute to a growing body of work on the importance of prosocial psychological processes for the promotion of public health behaviors such as handwashing and mask wearing during epidemics and pandemics (Pfatheicher et al., 2020; Puterman et al., 2009). Importantly, it expands past work by identifying positivity resonance, a marker of high-quality social connection, as a precursor to prosocial tendencies. Thus, this work is the first to our knowledge to spotlight the role of co-experienced positive affect in promoting adherence to behaviors that promote public health. This evidence bears implications for ongoing and future public health initiatives to address pathogen outbreaks in the US and other nations that face similar sociocultural barriers (i.e., 'loose' government structures, affective political polarization) and must therefore rely on individuals' prosocial motives to protect that nation's health.

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Figure 1

Confirmatory Factor Analysis of Prosocial Tendencies
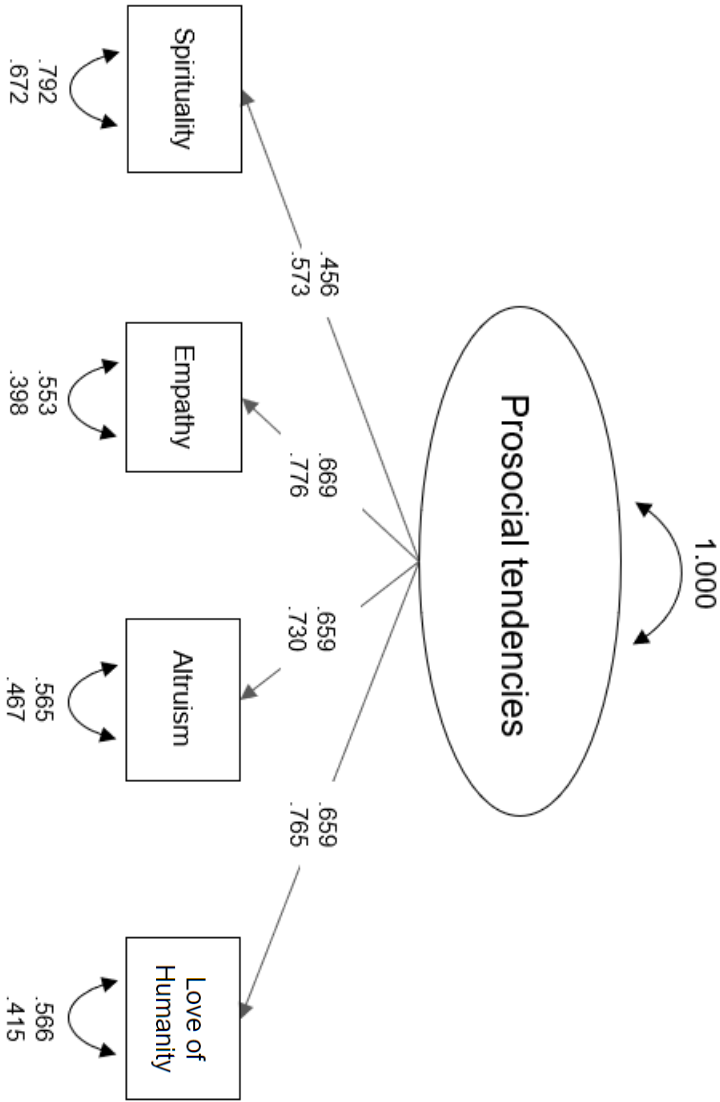
Note. Standardized coefficient estimates are reported sample both samples in a column of text, with the upper coefficients for Sample 1 and the lower ones for Sample 2. Although the raw factor loadings were fixed to be equal across samples, the standardized factor loadings differed across samples as standardization were done within sample. All factor loadings were significant (*ps* < .05).

Figure 2

Cross-sectional Indirect Effect of Positivity Resonance on T1 Covid-19-related Behaviors through Prosocial Tendencies (Study 1)
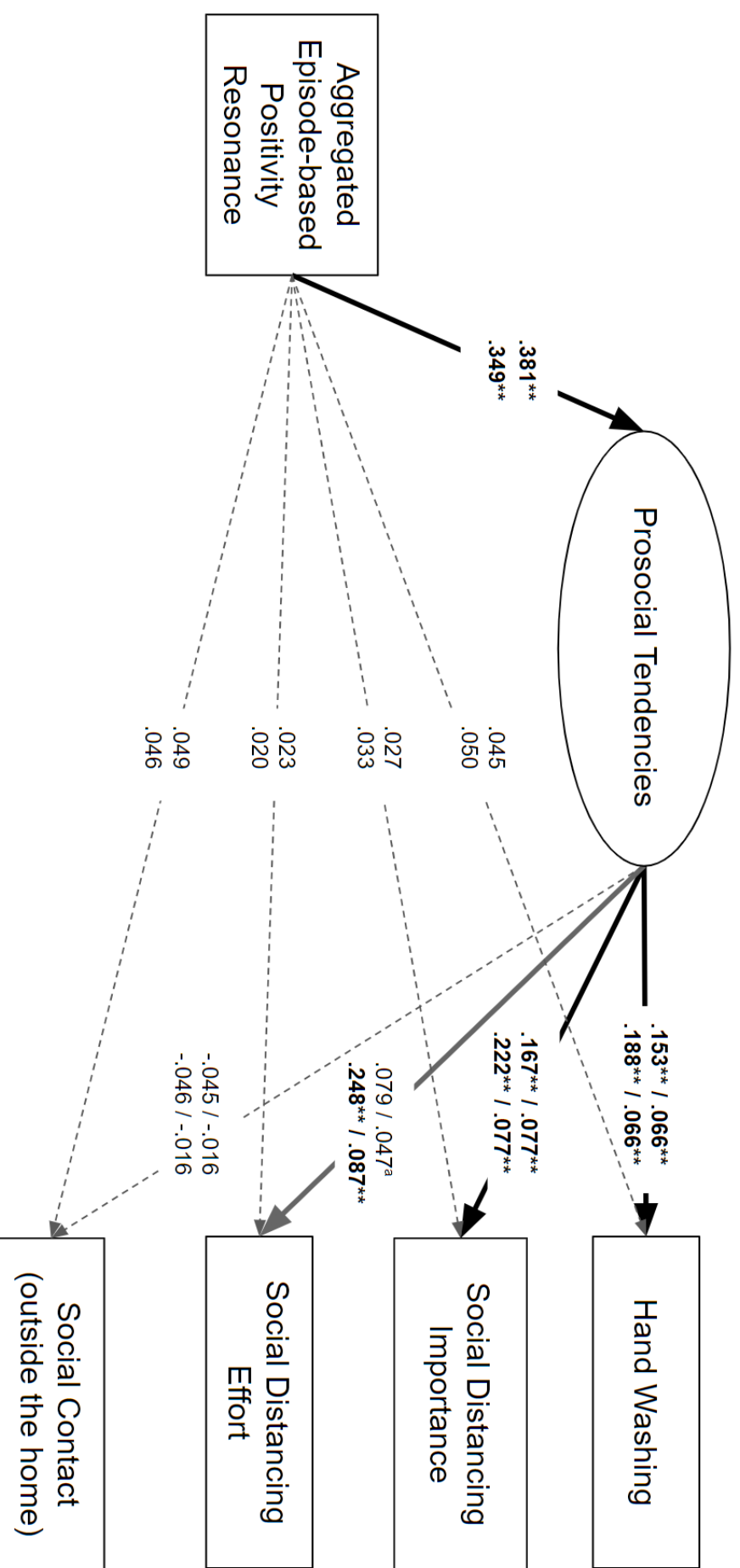
Note. Standardized coefficient estimates are reported for both samples in a column of text, with the upper coefficients for Sample 1 and the lower ones for Sample 2. Although the raw regression coefficients were fixed to be equal across group for all paths except from prosocial tendencies to social distancing effort, standardized coefficient estimates differed as standardization were done within sample. Coefficients before and after the forward slash (/) respectively show the direct effects of prosocial tendencies and the indirect effects of positivity resonance on behavior through prosocial tendencies. Unbroken and broken arrows respectively represent significant and insignificant paths. [a] This path was only significant for Sample 2 (MTurk Sample) and not Sample 1 (University Sample). ** indicates $p < .01$, and key significant parameters in the mediation model are bolded.

Figure 3

Longitudinal Indirect Effect of T1 Positivity Resonance on T3 Follow-up Covid-19-related Behaviors through T2 Prosocial Tendencies (Study 1)
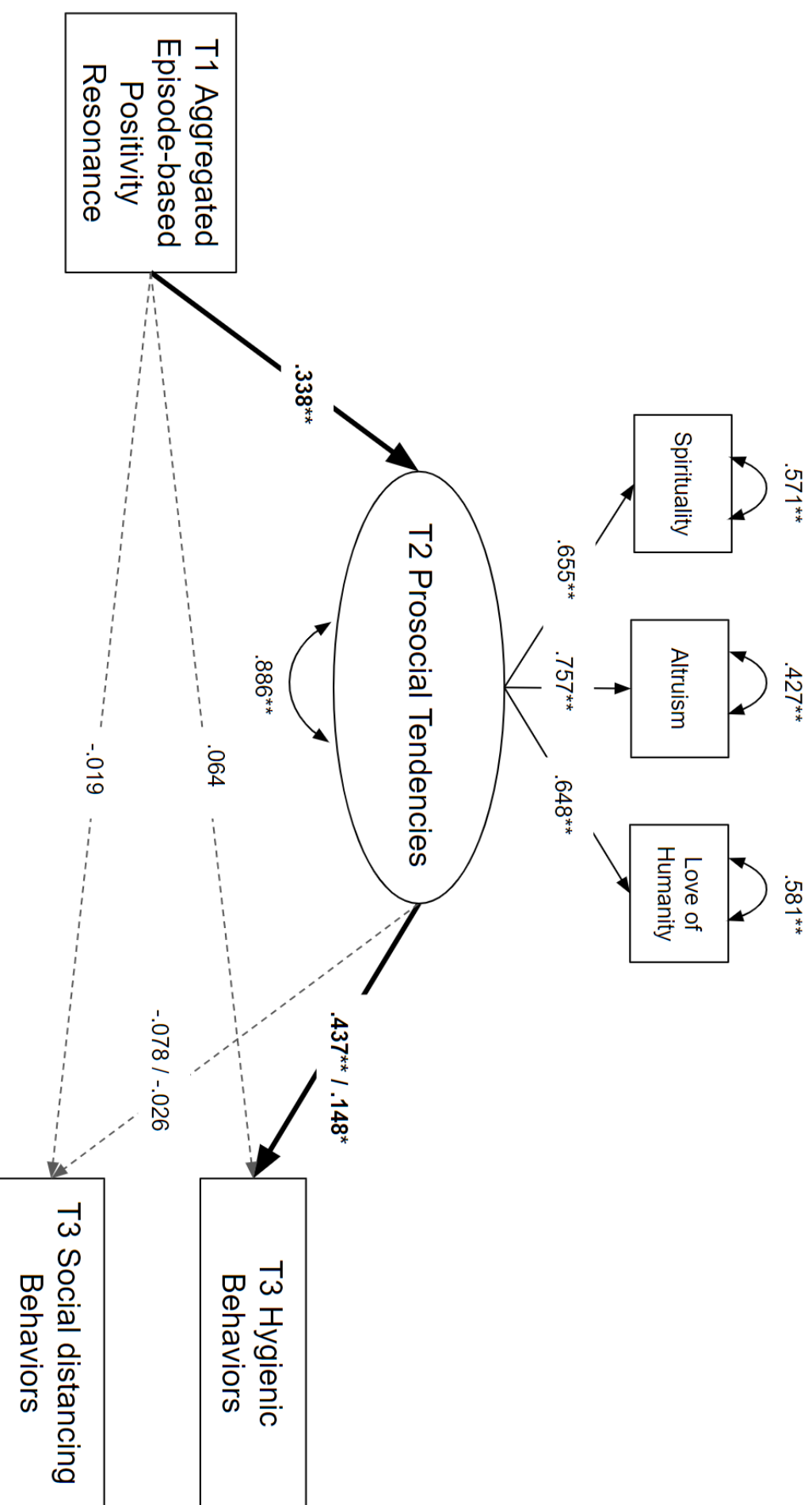
Note. Standardized coefficient estimates are reported. Coefficients before and after the forward slash (/) respectively show the direct effects of prosocial tendencies and the indirect effects of positivity resonance on behavior through prosocial tendencies. Unbroken and broken arrows respectively represent significant and insignificant paths. * indicates $p \leq .01$, and key significant parameters in the mediation model were bolded.

Figure 4

Replication of Hypothesized Indirect Effects Using Cross-sectional and Longitudinal Data from Study 2

7-Day Positivity Resonance

Prosocial tendencies

Spirituality

Altruism

Love of Humanity

Hygienic Behaviors

Social Distancing Behaviors

.485*
.591*

.503*
.377*

.717*
.640*

.705*
.790*

.578*
.551*

.666*
.696*

.749*
.685*

.501*
.561*

.035
.033

.043
.020

.258* / .129*
.267* / .183*

-.002 / .001
-.006 / .017
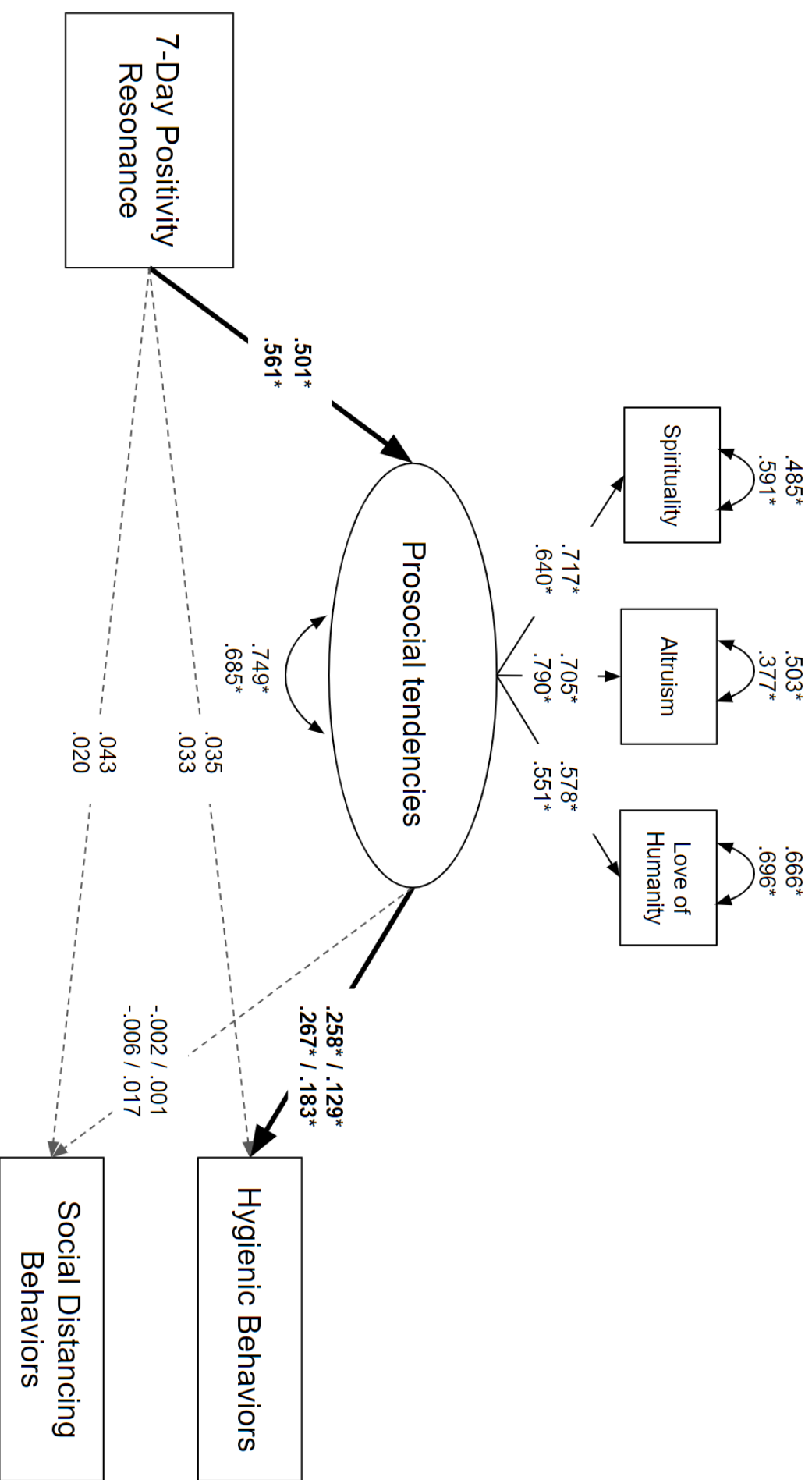
Note. Pre-pandemic and pandemic-era positivity resonance were tested in separate models. The upper and the lower standardized coefficients are for models that respectively analyzed pre-pandemic and pandemic-era positivity resonance. Coefficients before and after the forward slash (/) respectively show the direct effects of prosocial tendencies and the indirect effects of positivity resonance on behavior through prosocial tendencies. Unbroken and broken arrows respectively represent significant and insignificant paths. * indicates $p \leq .01$, and key significant parameters in the mediation model were bolded.

Table 1

Description of Primary Study Measures

Measure Name	Example items and response scale	# of Items	Study & Time Point	Temporal Focus	Alpha
Positivity Resonance					
Episode-based Positivity Resonance	Participants reported the proportion of time during the episode (from 0% to 100%) they had "…experienced a mutual sense of warmth and concern toward one another" and "…felt 'in sync' with the other(s)."	2	Study 1 (T1)	Episodes within a day (aggregated to obtain one day measure)	.87-.89
Daily Positivity Resonance	Full 7-item scale from Major et al., 2018	7	Study 2 (Pre-pandemic & Pandemic era)	Daily (aggregated over 7 days)	.99
Prosocial Tendencies					
Spirituality	(1) In the past week, I set aside time for an activity that I consider spiritual. (experienced) (2) In the past week, I had a feeling of strong connection to all life. (enacted) 1 = strongly disagree to 7 = strongly agree	2	Study 1 (T1 &T2), Study 2 (Pandemic era)	Daily (aggregated over 7 days)	.47-.64
Empathy	(1) I often have tender, concerned feelings for people less fortunate than me. (empathic concern) (2) I sometimes try to understand my friends better by imagining how things look from their perspective. (perspective taking) 1 = does not describe me at all to 5 = describes me very well	8	Study 1 (T1)	General	.82-.84
Altruism	(1) Whether it was big or small, I went out of my way to help someone in the past week. (enacted) (2) I felt compassion for others in the past week. (experienced) 1 = strongly disagree to 7 = strongly agree	2	Study 1 (T1 &T2), Study 2 (Pandemic era)	Daily (aggregated over 7 days)	.63-.71
Love of Humanity	(1) I believe that people are inherently good. (2) Because we are all in this life together, it's important to look out for one another. (3) I feel that my life is meaningfully intertwined with the lives of others, even people I don't know. (4) There are times in my life when I've felt strong feelings of love for all people, not just the specific people I'm close to. (5) I believe that people treat each other kindly more often than not. 1 = completely disagree to 7 = completely agree	5	Study 1 (T1 & T2), Study 2 (Pandemic era)	General	.68-.78
Health Behaviors					
Hygiene simple	*Hand Washing:* In the past week, how often have you washed your hands for 20 seconds or longer? 0= never to 5= 5 or more times a day	1	Study 1 (T1)	Past week	N/A

Measure	Items	#	Study	Timeframe	α
Hygiene composite	Participants were asked how often in the past week they had washed/sanitized their hands (1) immediately upon entering their home (2) after handling packages/deliveries to their home (3) after exiting a grocery store or business (4) how often they coughed/sneezed into their elbow, rather than their hand. (5) how often have they worn a mask or other face covering when in public or in close proximity with others. 0= never to 3= always, or not applicable	5	Study 1 (T2 &T3), Study 2 (Pandemic-era)	Past week	.58-.73
Social distancing Simple	*Perceived SD Importance:* Social distancing is important right now. 1 = strongly disagree to 7 = strongly agree *Perceived SD Effort:* How much effort have you put toward social distancing? 1= no effort to 5= a great deal of effort *Social Contact outside the home:* In the past week, how many days have you been in physical proximity to people who do not live with you? (e.g., meeting friends, at the grocery store, outside) 0 = never to 7 = all 7 days	3	Study 1 (T1)	General or Past week	N/A
Social distancing composite	Participants were asked how many times in the past week they had (1) visitors in their home or visited others (2) dined at a cafe or restaurant (3) gathered with people outside their household at an outdoor location (4) touched someone outside their household. (5) stayed at least 6 feet away from other people outside the home 0 = never to 3 = always, or not applicable.	5	Study 1 (T2 &T3), Study 2 (Pandemic era)	Past week	.58-.77

Note. In Study 1, only Sample 2 completed follow-up assessments. For all 2-item measures, standardized coefficient alphas are reported (Eisinga et al., 2012).

Table 2

Descriptive Statistics on Social Interactions Reported for Samples 1 and 2 of Study 1

	Avg. # of Episodes		Rescaled Positivity Resonance (0 - 10)		Concern for Virus	
	Sample 1 (*N* = 484)	Sample 2 (*N* = 575)	S1 Means (SD)	S2 Means (SD)	S1 Means (SD)	S2 Means (SD)
Social Target						
Family	3.2 (*n* = 385)	3.4 (*n* = 407)	5.96 (2.43)	7.02 (2.40)	1.47 (.85)	2.44 (1.90)
Partner	3.4 (*n* = 171)	3.4 (*n* = 254)	6.71 (2.35)	7.62 (2.13)	1.69 (.99)	2.35 (1.92)
Friend	3.1 (*n* = 404)	2.4 (*n* = 311)	5.71 (2.45)	6.62 (2.34)	1.64 (1.14)	2.98 (2.20)
Co-worker	1.7 (*n* = 131)	2.3 (*n* = 231)	4.34 (2.56)	5.27 (2.51)	2.27 (1.72)	3.35 (2.17)
Stranger	1.7 (*n* = 212)	1.9 (*n* = 219)	3.86 (2.57)	4.65 (2.76)	2.77 (2.00)	3.99 (2.24)
Mode of Interaction	%	%				
Face to Face	48	47	6.26 (n=409)	7.10 (n=361)		
Digital synchronous	30	24	5.82 (n=307)	6.38 (n=202)		
Digital asynchronous	22	29	4.75 (n=264)	5.39 (n=262)		

Note. "Concern for virus" refers to the average level of concern for spreading or contracting COVID-19 (assessed only for face-to-face interactions). An uppercase N indicates the total sample size, whereas the lowercase n indicates the size of a subset of the sample who reported a specific type of interaction.

Table 3

Means, standard deviations, and correlations among Study 1 main-model variables

Variable	n	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. T1 Positivity Resonance	1017	6.15	2.26															
2. T1 Spirituality	1056	4.61	1.45	.25**														
3. T1 Empathy	1056	3.88	.64	.26**	.25**													
4. T1 Altruism	1056	5.69	1.05	.22**	.38**	.33**												
5. T1 Love of humanity	1055	5.08	.96	.25**	.42**	.54**	.54**											
6. T2 Spirituality	300	4.75	1.42	.19**	.72**	.31**	.32**	.47**										
7. T2 Altruism	300	5.53	1.12	.23**	.39**	.54**	.58**	.46**	.44**									
8. T2 Love of Humanity	300	5.03	1.02	.22**	.42**	.51**	.44**	.72**	.45**	.48**								
9. T1 Hand Washing	1059	4.01	1.12	.13**	.06*	.17**	.08**	.17**	-.01	.20**	.15*							
10. T1 Social Distancing Importance	1059	6.50	.96	.12**	.00	.21**	.18**	.15**	.10	.23**	.21**	.20**						
11. T1 Social Distancing Effort	1059	4.57	.71	.10**	.02	.22**	.17**	.09**	.08	.20**	.19**	.24**	.52**					
12. T1 Social Contact (outside home)	1054	1.91	1.83	.04	.04	-.08*	-.03	.03	.06	.00	-.02	-.01	-.20**	-.34**				
13. T2 Hygienic behaviors	291	3.48	.66	.22**	.08	.33**	.25**	.14*	.13*	.23**	.39**	.34**	.43**	-.24**				
14. T2 Social Distancing behaviors	300	3.71	.48	.05	-.12*	.10	.04	.05	-.11	.05	.27**	.36**	.40**	-.31**	.44**			
15. T3 Hygienic behaviors	281	3.46	.64	.21**	.15*	.33**	.20**	.25**	.18**	.28**	.23**	.28**	.37**	-.19**	.62**	.24**		
16. T3 Social Distancing behaviors	283	3.46	.62	-.05	-.15*	.13*	-.03	.03	-.11	-.09	.00	.19**	.36**	-.28**	.25**	.54**	.33**	

Note. Statistics characterize data collapsed across Sample 1 and Sample 2. *M* and *SD* are used to represent mean and standard deviation, respectively. * *p* <.05. ** *p* <.01.

Table 4

Means, standard deviations, and correlations between main-model variables and control variables

Variable	n	M	SD	T1 Positivity Resonance	T1 Spirituality	T1 Empathy	T1 Altruism	T1 Love of humanity	T2 Spirituality	T2 Altruism	T2 Love of humanity	T1 Wash hand	T1 Social Distancing Importance	T1 Social Distancing Effort	T1 See others outside	T2 Hygienic behaviors	T2 Social Distancing behaviors	T3 Hygienic behaviors	T3 Social Distancing behaviors
T1 Positive emotions	1059	2.36	.75	.48**	.28**	.18**	.23**	.26**	.18**	.17**	.24**	.08*	.08**	.05	.07*	.10	.01	.10	-.07
T1 Negative emotions	1059	1.10	.85	-.19**	.01	-.01	-.07*	-.03	.10	-.02	.03	-.13**	-.11**	-.13**	.14**	-.16**	-.32**	-.14*	-.27**
T1 No. of social episodes	1018	5.19	3.11	.11**	.06	.10**	.14**	.09**	-.05	.06	-.04	.01	.10**	.05	.10**	.03	.06	-.03	-.12*
T1 Political orientation	1055	3.40	1.73	.10**	.22**	-.14**	-.11**	-.06*	.21**	-.04	-.10	-.06*	-.21**	-.20**	.20**	-.18**	-.26**	-.17**	-.27**
T1 Age	1056	29.28	11.90	.19**	.07*	.05	-.02	.08**	.04	.13*	.06	.12**	.04	.07*	.04	-.02	.07	.08	.10
T1 Gender	1059	1.59	.50	.00	-.03	.12**	.16**	.07*	.04	.11	.03	.03	.17**	.17**	-.07*	.06	.09	.04	-.06
T1 Education	1059	3.43	.85	.05	.04	-.03	-.06*	.10**	.13*	-.02	.17**	.01	-.01	-.02	.06	-.11	-.09	.04	-.04
T1 Asian	1059	.21	.41	-.07*	-.14**	-.06*	-.09**	-.05	-.08	-.09	-.03	-.08**	.08**	.07*	-.15**	.06	.10	.10	.17**
T1 Non-Asian POC	1059	.28	.45	.01	.10**	.08**	.06	.04	.10	-.01	.00	-.01	-.09**	-.01	.07*	.03	-.16**	.06	-.03
T1 Self Concern	1059	4.13	2.00	.13**	.13**	.09**	.01	.06	.13*	.09	.11	.14**	.17**	.15**	.01	.13*	-.01	.24**	.06
T1 Illness Symptoms	1058	2.01	1.38	.03	.10**	-.01	-.01	.03	.06	.01	.06	-.09**	-.12**	-.15**	.22**	-.11	-.35**	-.14*	-.30**
T1 High-risk self	1050	.16	.37	.03	.04	.05	.05	.08*	-.17**	.03	-.07	.08**	-.02	.00	.03	-.15*	-.09	-.02	-.09
T1 Live with high-risk others	1050	.27	.44	-.04	.02	.03	.02	.02	.07	.07	-.02	-.03	.00	.05	-.03	.05	-.02	.04	.02
T1 no. of people tested for COVID-19	1059	.03	.17	.05	.06*	-.03	-.07*	.00	.12*	.03	.11	-.08*	-.08**	-.10**	.09**	-.10	-.22**	-.03	-.06
T1 positive diagnoses	1054	.01	.10	.03	.00	-.07*	-.14**	-.01	.02	-.07	-.09	-.07*	-.10**	-.16**	.08*	-.08	-.16**	-.02	-.09
Cumulative no. of people tested for COVID-19	1059	.07	.26	.05	.07*	-.01	-.05	.04	.01	-.01	.11*	-.06*	-.05	-.07*	.08*	-.15**	-.24**	.06	-.08
Cumulative positive diagnoses	1059	.02	.12	.02	.02	-.04	-.09**	.01	.09	.03	.05	-.04	-.07*	-.12**	.05	-.09	-.13*	.01	-.09

Note. Statistics characterize data collapsed across Sample 1 and Sample 2. *M* and *SD* are used to represent mean and standard deviation, respectively. * $p < .05$. ** $p < .01$.

Table 5

Model fits of multi-group CFAs and SEMs

CFA models	Invariance type	$\chi 2$	df	CFI	RMSEA	SRMR	Contrast	$\Delta\chi 2$	Δdf	p
1	Configural	26.129	4	.979	.102	.023	-	-	-	-
2	Metric	29.382	7	.979	.078	.029	2 vs. 1	3.253	3	.354
3	Full Scalar	64.949	10	.948	.102	.047	3 vs. 2	35.567	3	<.001
Indirect effect models	Constraint type									
1	Freely estimate regression paths	99.732	37	.965	.058	.035	-	-	-	-
2	Complete equality constraint	122.116	46	.957	.057	.045	2 vs. 1	22.384	9	.008
3	Partial equality constraint	112.501	45	.962	.054	.040	3 vs. 1	12.769	8	0.120

Table 6

Means, standard deviations, and correlations among Study 2 variables

Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Pre-pan PosRes	7.30	1.53																	
2. Pandemic PosRes	7.60	1.54	.52**																
3. Spirituality	4.61	1.19	.37**	.30**															
4. Altruism	5.31	.80	.34**	.47**	.30**														
5. Love of Humanity	5.20	.88	.30**	.31**	.47**	.51**													
6. Hygienic Behaviors	2.54	.59	.12	.18**	.17**	.40**	.40**												
7. Social Distancing Behaviors	2.56	.48	.08	.02	.21**	.34**	.36**	.24**											
8. Positive Affect	3.52	.69	.47**	.34**	.34**	.21**	-.02	.07	-.06										
9. Negative Affect	2.15	.73	-.20**	-.24**	-.23**	-.11	-.30**	-.06	.08	-.47**									
10. Politics	2.74	1.45	.05	.04	.10	.01	-.13*	-.20**	-.12	.02	-.04								
11. Gender	1.82	.38	.09	.08	.07	.06	.09	.08	.03	.13	.03	-.04							
12. Age	34.52	11.37	.09	-.04	.04	-.04	.13	.16*	.06	-.15*	.06	.07	-.04						
13. Nonwhite	.29	.45	-.04	-.11	-.02	-.22**	-.12	-.02	.06	-.03	.02	.00	-.04	-.04					
14. Education	5.27	1.13	.05	.02	.11	.10	.11	.16*	.16*	.04	-.10	.09	.06	.04	.09				
15. Feeling ill	1.51	.54	-.14*	-.20**	-.04	-.10	-.22**	-.08	-.07	-.17**	.34**	.08	-.01	-.09	.09	-.05			
16. At risk	.15	.36	.15*	.13	.11	.10	-.02	.09	.19**	-.01	-.05	.03	.06	.20**	.09	-.10	-.10		
17. Live with at-risk others	.17	.37	-.02	.02	.06	.13	.04	.12	-.03	-.06	.02	.11	.15*	.11	-.02	.03	.02	.01	
18. Tested for COVID-19	.02	.15	.06	.06	.13	.07	.00	-.17*	-.08	.10	.06	.11	-.01	-.09	-.10	-.05	-.10	.11	-.07

Note. M and SD are used to represent mean and standard deviation, respectively. * indicates $p < .05$. ** indicates $p < .01$.

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