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ORIGINAL RESEARCH REPORT

Did Social Connection Decline During the First Wave of COVID-19?: The Role of Extraversion

Dunigan Folk[*], Karynna Okabe-Miyamoto[†], Elizabeth Dunn[*] and Sonja Lyubomirsky[†]

In two pre-registered studies, we tracked changes in individuals' feelings of social connection during the COVID-19 pandemic. Both studies capitalized on measures of social connection and well-being obtained prior to the COVID-19 pandemic by recruiting the same participants again in the midst of the pandemic's upending effects. Study 1 included a sample of undergraduates from a Canadian university ($N = 467$), and Study 2 included community adults primarily from the United States and the United Kingdom ($N = 336$). Our results suggest that people experienced relatively little change in feelings of social connection in the face of the initial reshaping of their social lives caused by the COVID-19 pandemic. Exploratory analyses suggested that relatively extraverted individuals exhibited larger declines in social connection. However, after controlling for levels of social connection prior to the pandemic (as pre-registered), the negative effect of extraversion reversed (Study 1) or disappeared (Study 2).

On March 11, 2020, the World Health Organization (WHO) designated COVID-19 as a pandemic (WHO, 2020), and less than a month later, approximately 95% of the U.S. population had been instructed to stay at home (Mervosh, Lu, & Swales, 2020). In countries around the world, individuals were encouraged—or even ordered—to engage in "physical/social distancing," staying at least 6 feet (2 meters) from anyone outside their own household (CDC, 2020). Did this radical change in everyday social behavior alter people's subjective sense of social connection? The answer might hinge on individuals' personal characteristics. In particular, introverts and extraverts exhibit fundamentally different approaches to social life (Smillie, Kern, & Uljarevic, 2019; Zelenski, Sobocko, & Whelan, 2014), suggesting that the effects of physical distancing might vary depending on individuals' extraversion levels.[1]

Depriving people of social contact may substantially reduce their positive feelings of interpersonal closeness and belonging, while increasing loneliness and perceived isolation (Baumeister & Leary, 1995; Lee, Draper, & Lee, 2001; Russell, Peplau, & Cutrona, 1980; Ryan & Deci, 2000). Although these *subjective* feelings of social connection are theoretically distinct from *objective* social behavior (e.g., number of interactions), the two constructs are related. In an intensive study of over 250 college students, *every* participant reported feeling less socially connected, on average, following an hour without social interaction (compared to an hour that included social interaction; Sun, Harris, & Vazire, 2019). In another study, adults in Canada reported having six in-person interactions with close others and eleven interactions with strangers or acquaintances on a typical day, and they reported lower feelings of belonging on days when they had fewer interactions than usual (Sandstrom & Dunn, 2014). If physical distancing reduces these daily social interactions, then feelings of social connection could be expected to drop considerably during the COVID-19 pandemic. Although collective trauma can potentially bring people together (Cohn, Mehl, & Pennebaker, 2004; Pennebaker & Harber, 1993), physical distancing restrictions might make it more difficult to act on the desire to connect with others.

Alternatively, even if people's opportunities for social contact are severely curtailed by physical distancing restrictions, their subjective feelings of social connection could remain steady or even increase. If humans have a fundamental need to belong (Baumeister & Leary, 1995), then they should find alternate ways to satisfy this need when deprived of their usual sources of social connection. Consistent with this perspective, people have organized video "happy hours" (e.g., Tiffany, 2020) and cheered with their neighbors for frontline workers (e.g., Hess, 2020). These acts of solidarity could plausibly satisfy the need to belong, such that the pandemic could produce unchanged—or even elevated—feelings of connection.

As these examples highlight, the psychological consequences of COVID-19 likely depend on people's pre-existing social networks and on their social behavior

* University of British Columbia, CA

† University of California, Riverside, CA

Corresponding author: Dunigan Folk (duniganfolk@psych.ubc.ca)

during the pandemic. Compared to introverts, extraverts tend to have stronger social relationships, which could serve as a buffer during a crisis such as the COVID-19 pandemic. Specifically, extraverts typically have higher quality relationships (Harris, English, Harms, Gross, & Jackson, 2017), are more satisfied with their friendships (Wilson, Harris, & Vazire, 2015), and have higher levels of perceived social support (Swickert, Rosentreter, Hittner, & Mushrush, 2002; Tan, Krishnan, & Lee, 2017; Boyraz, Horne, & Sayger, 2012) relative to introverts. Extraverts also have larger social networks (Harris et al., 2017; Lang, Staudinger, & Cartensen, 1998), giving them more people to turn to for support during a challenging time. Thus, extraverts may exhibit smaller declines in feelings of social connection compared to their introverted peers.

It is also possible, however, that introverts would be less adversely affected by physical distancing policies. Because introverts typically have fewer social interactions than extraverts (Harris et al., 2017; Lucas, Le, & Dyrenforth, 2008; Srivastava, Angelo, & Vallereux, 2008), physical distancing requirements might produce relatively small shifts in their behavior, leaving their subjective feelings of social connection unscathed. This idea is reflected in numerous internet memes showing introverts learning that their "normal lifestyle is called quarantine" and they should "check on extraverted friends" (see #introvertmemes on Twitter).

Finally, even if introverts and extraverts show similar shifts in their sense of social connection, feeling connected may be a more essential source of extraverts' overall well-being. Extraversion is robustly associated with higher subjective well-being (Anglim, Horwood, Smillie, Marrero, & Wood, 2020; Steel, Schmidt, & Shultz, 2008). However, the relationship between extraversion and happiness may be explained by other core features of extraversion, such as energy level, as opposed to sociability (Margolis, Stapley, & Lyubomirsky, 2020). As such, it is an open question whether extraverts' and introverts' overall well-being will be differentially affected by any changes in feelings of social connection during the pandemic.

The Present Research

In two pre-registered studies with 467 undergraduates from a Canadian university (Study 1) and 336 adults primarily from the U.S. and U.K. (Study 2), we capitalized on measures of social connection and well-being obtained prior to the pandemic. We surveyed the same individuals again in the midst of the pandemic, enabling us to examine within-person change. The two studies were spearheaded by independent labs in different countries and used somewhat different measures and designs. Yet, both studies enabled us to test whether people reported higher or lower feelings of social connection during the COVID-19 pandemic, compared to before. In addition, we tested whether this change in social connection varied for extraverts and introverts. Lastly, we investigated whether the effect of any social connection changes on well-being differed for extraverts versus introverts.

Study 1

University of British Columbia (UBC) undergraduates completed our dependent measures prior to the COVID-19 pandemic as part of department-wide pre-screening (T_1) and again during the COVID-19 pandemic (T_2). Our pre-registered stopping rules, research questions, and analysis plan for Study 1 are available on the Open Science Framework (OSF) at https://tinyurl.com/ybwz8ufb.

Method

Time₁

During department-wide pre-screening, undergraduates completed demographic items and a measure of social connection. Although the pre-screening battery did not contain a standard measure of subjective well-being, it did include a measure of lethargy, which we used as a rough proxy for well-being. The pre-screening survey opened on January 6, 2020. Students could complete the survey anytime, and we included 2,903 participants who completed it by February 12, 2020 (for consistency with Study 2). Although Time₁ data were collected prior to our pre-registration, we did not conduct any analyses until after pre-registering and collecting Time₂ data.

Time₂

From April 1–8, 2020, we invited all students who had completed pre-screening to complete the same measures of social connection and lethargy again for partial course credit or a chance to win a $250 Amazon gift card. In addition, the Time₂ survey included a measure of extraversion, as well as other exploratory measures (e.g., about students' experiences during COVID-19). Our final sample included 467 participants (age: M = 20.89, SD = 3.03; 77% women) who completed both our Time₁ and Time₂ surveys and met our inclusion criteria. These participants did not differ in connectedness, lethargy, or household income at Time₁ compared to remaining eligible members of the participant pool who had completed pre-screening by February 12th ($p's$ > .30). This sample size gave us 80% power to detect effects of at least d = .13. Our dataset for this final sample is available on the OSF at https://tinyurl.com/yaa3qz2o.

Measures

The following measures are available on the OSF at https://tinyurl.com/y9kdyk5s.

Social Connection

Social connection was measured using the revised 20-item Social Connectedness Scale (Lee et al., 2001). Participants rated their agreement with items such as "I feel understood by the people I know" and "I feel close to people" (1 = *strongly disagree*, 6 = *strongly agree*). As pre-registered, we removed one item from both timepoints ("I feel comfortable in the presence of strangers"), given its potentially different meaning during the pandemic. At Time₁, participants completed the survey with regard to their general self-views (α = .95). At Time₂, because participants had been experiencing rapid change in their daily lives, we asked them to consider the past week (α = .94).

Lethargy

Participants completed a newly developed 10-item measure assessing mental and physical fatigue in the present moment, with items such as "I am lacking in energy" and "I am fatigued right now" (1 = *not at all*, 6 = *extremely*; Bourrier, in prep.). Because of the association between fatigue and low well-being (e.g., Smith, 2018), we used this measure (which we label "lethargy") as a proxy[2] for well-being at Time$_1$ (α = .95) and Time$_2$ (α = .95).

Extraversion

At Time$_2$, students completed the 12-item extraversion subscale of the Big Five inventory-2 (BFI-2; Soto & John, 2017; α = .88), as well as 3 items tapping each of the other personality facets (e.g., conscientiousness; BFI-2-XS; Soto & John, 2017). Participants rated their agreement with statements like, "I am someone who is outgoing, sociable" and "I am someone who is sometimes shy, introverted" (1 = *strongly disagree*, 7 = *strongly agree*). Because we were interested in students' typical personalities rather than their behavior during the pandemic, we asked them to "think back to life before Covid-19—before social distancing was required and before your day-to-day life was disrupted." Immediately after rating their personality, participants were asked to indicate whether they answered the scale with regard to their "typical personality prior to the COVID-19 pandemic" or their "personality during the COVID-19 pandemic." As pre-registered, we excluded 142 participants who answered the latter or failed to answer.

Physical Distancing

For descriptive purposes, we asked participants whether or not they were currently practicing physical/social distancing and how many non-household members got within 6 feet of them on the previous day.

Additional Exclusion Criteria

Following our current lab practice, to screen out inattentive participants, we excluded individuals who provided the same answer 12 times in a row on either the connectedness measure or the BFI, as pre-registered. We failed to pre-register a strategy for managing missing data. Prior to downloading our Time$_2$ data, however, we decided to exclude participants from either timepoint who missed more than ~20% of the items on our critical measures (i.e. 2 out of 10 from our measure of lethargy, 3 out of 12 on extraversion, 3 out of 19 on connectedness); our full authorship team agreed on these cut-offs because they seemed appropriately cautious yet not overly conservative, while accounting for differences in scale length. If participants were missing data below these cut offs, we used the mean of each individual's remaining responses to impute their missing responses. Finally, if participants completed the Time$_2$ survey twice (which we did not foresee), we used only their first survey response.

Study 1 Results

Consistent with our assumption that participants had curtailed their direct social contacts at Time$_2$, almost all participants (98.5%) reported practicing physical/social distancing, and most participants indicated that no one outside their household came within 6 feet of them the day before (*Mode* = 0, *M* = 0.77, *SD* = 1.39). The R code used for the following analyses is available on the OSF at https://tinyurl.com/y724olob.

Has social connection changed as a result of the COVID-19 pandemic?

Pre-Registered Analysis

Using a paired-sample *t*-test, we found that participants reported lower levels of social connection during the COVID-19 pandemic (Time$_2$: *M* = 3.97, *SD* = 0.85) than before (Time$_1$: *M* = 4.11, *SD* = 0.88), *t*(466) = 4.19, *p* < .001 (see **Table 1** for means and correlations between all Time$_1$ and Time$_2$ variables). However, this drop in connectedness was small (*d* = 0.16, 95% CI = [0.03, 0.29];[3] see **Figure 1**).

Has social connection changed more for extraverts or introverts?

Pre-Registered Analysis

We first examined whether extraversion was linked to Time$_2$ social connectedness after controlling for Time$_1$ social connectedness. Specifically, as pre-registered, we entered extraversion and Time$_1$ social connectedness

Table 1: Means and Correlations Among Variables at Time 1 and Time 2 (Study 1).

	T1 Lethargy	T2 Lethargy	Lethargy diff (T2−T1)	T1 Social connectedness	T2 Social connectedness	Connectedness diff (T2−T1)	Extraversion
T1 Lethargy	1						
T2 Lethargy	.41	1					
Lethargy diff (T2−T1)	−.48	.60	1				
T1 Social connectedness	−.48	−.27	.16	1			
T2 Social connectedness	−.36	−.41	−.08	.66	1		
Connectedness diff (T2−T1)	.16	−.16	−.30	−.45	.38	1	
Extraversion	−.28	−.14	.11	.56	.50	−.09	1
Mean (SD)	2.60 (1.16)	3.16 (1.27)	0.56 (1.33)	4.11 (0.88)	3.97 (0.85)	−0.14 (0.71)	4.17 (1.01)

into a multiple regression predicting $Time_2$ social connectedness. In this model, extraversion was positively associated with $Time_2$ social connectedness, $b = .16$, 95% CI = [0.10, 0.22], $p < .001$ (see **Table 2**, Model 1).

Exploratory Analyses

An alternate analytic strategy for capturing change over time is to enter extraversion into a regression predicting change in social connectedness ($Time_2 – Time_1$). In this

exploratory model, we found that extraversion was weakly associated with declines in social connectedness, $b = –0.06$, 95% CI = [–0.13, 0.00], $p = .049$ (see **Table 2**, Model 2). To unpack this finding, we split our sample into those with an extraversion score at or below the 25th percentile and those at or above the 75th percentile. Our most introverted participants exhibited a small drop ($d = 0.14$, 95% CI = [–0.11, 0.39]) in social connectedness between $Time_1$ ($M = 3.45$, $SD = 0.70$) and
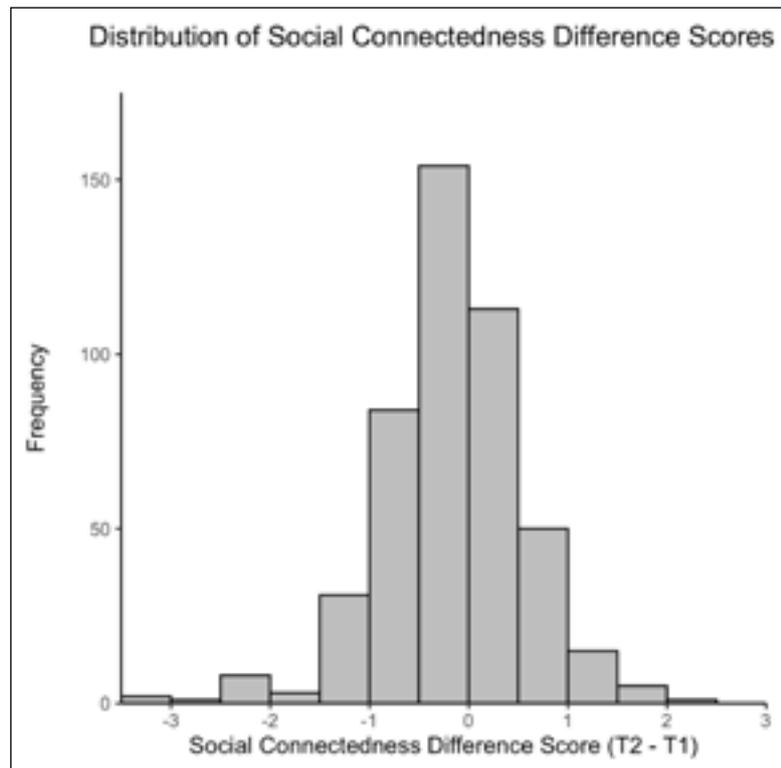

Figure 1: Distribution of social connectedness difference scores (Study 1).

Table 2: Results of Multiple Regression Models (Study 1).

Dependent variable and predictors	df	Adjusted R^2	b(SE)	95% CI	β	t	p
Time 2 social connectedness (Model 1)[a]	464	.46					
Time 1 social connectedness			0.53 (0.04)	[0.45, 0.61]	0.55	13.37	<.001
Extraversion			0.16 (0.03)	[0.10, 0.22]	0.20	4.74	<.001
Social connectedness difference score (T2–T1; Model 2)[b]	465	.006					
Extraversion			–0.06 (0.03)	[–0.13, 0.00]	–0.09	–1.97	.049
Lethargy difference score (T2–T1; Model 3)[a]	463	.09					
Social connectedness difference score (T2–T1)			–0.84 (0.37)	[–1.57, –0.10]	–0.45	–2.24	.026
Extraversion			0.12 (0.06)	[0.00, 0.23]	0.09	1.96	.051
Extraversion × Social connectedness difference score			0.07 (0.08)	[–0.10, 0.23]	0.16	0.81	.418
Lethargy difference score (T2–T1; Model 4)[a]	462	.28					
Social connectedness difference score (T2–T1)			–0.82 (0.33)	[–1.47, –0.16]	–0.44	–2.46	.014
Extraversion			–0.04 (0.05)	[–0.15, 0.07]	–.03	–0.746	.456
Time 1 Lethargy			–0.52 (0.05)	[–0.62, –0.43]	–0.46	–11.03	<.001
Extraversion × Social connectedness difference score			0.09 (0.07)	[–0.06, 0.24]	0.22	1.221	.223

Note: [a] pre-registered analysis; [b] exploratory analysis.

Time$_2$ (M = 3.35, SD = 0.66); t(118) = 1.73, p = .087; whereas the most extraverted participants exhibited a larger drop (d = 0.33, 95% CI = [0.08, 0.58]) in social connectedness between Time$_1$ (M = 4.70, SD = 0.72) and Time$_2$ (M = 4.45, SD = 0.84); t(129) = 3.49; p < .001.

Thus, the effect of extraversion appears to hinge on whether we control for Time$_1$ social connectedness; extraverts exhibited a greater drop in connectedness compared to introverts, but this larger decline can be explained by the high level of social connectedness they experienced prior to the pandemic.

Is the effect of change in social connection on well-being different for extraverts and introverts?
Pre-Registered Analyses
To test whether changes in connectedness have a larger effect on lethargy for individuals high in extraversion, we conducted a multiple regression model predicting change in lethargy (T$_2$–T$_1$) from change in social connectedness (T$_2$–T$_1$), extraversion, and the Extraversion × Change in Social Connectedness interaction. The relationship between social connectedness change and lethargy change was not moderated by extraversion (see **Table 2**, Model 3). These results were substantively unchanged when we controlled for Time$_1$ lethargy (see **Table 2**, Model 4; also see Table S1, Model S1 in Supplemental Material for an alternate modeling approach).

Exploratory Analyses
To test whether momentary lethargy levels changed from before to during the pandemic, we conducted a paired-samples t-test; lethargy increased from Time$_1$ (M = 2.60, SD = 1.16) to Time$_2$ (M = 3.16, SD = 1.27); t(466) = 9.21, p < .001; d = 0.46, 95% CI = [0.33, 0.60]. Furthermore, changes in social connectedness were significantly correlated with changes in lethargy, r(465) = −.30, p < .001, such that decreases in connectedness were associated with increases in lethargy.

Study 1 Discussion
University students reported significantly lower levels of social connectedness during the COVID-19 pandemic compared to their own levels before the pandemic, but this decline was small in magnitude (just over a tenth of a point on a 6-point scale). Exploratory analyses showed that our most extraverted participants exhibited a larger drop in social connectedness than our most introverted participants. However, when we controlled for levels of connectedness prior to the pandemic (as pre-registered), extraverts fared better than introverts. In other words, if an introvert and an extravert started with identical levels of social connectedness prior to COVID-19, the extravert would experience a smaller drop than the introvert. Students also reported increased feelings of lethargy during the pandemic (by about half a point on a 6-point scale). For introverts and extraverts alike, experiencing bigger drops in social connectedness was associated with experiencing greater increases in lethargy.

However, our reliance on college students limits generalizability. In addition, our survey prior to the pandemic did not include a standard measure of well-being, and

therefore we only examined changes in lethargy (as a proxy). Perhaps most important, our survey before the pandemic did not include an extraversion measure, and thus we asked participants to think about their personality prior to COVID-19. Supporting the effectiveness of this approach, our extraversion measure was more highly correlated with connectedness prior to the pandemic than with connectedness during the pandemic (see **Table 1**). Study 2 addresses the weaknesses of Study 1 by examining a more diverse sample of adults, who completed standard measures of well-being and extraversion prior to the pandemic.

Study 2
Adults from the U.S., the U.K., and 26 other countries completed our measures both prior to the COVID-19 pandemic (Time$_1$) and again during the pandemic (Time$_2$). The pre-registered stopping rules, research questions, and analysis plan for Study 2 are available on the OSF at https://tinyurl.com/y9uz6npe.

Method
Time$_1$
Participants (N = 386; age: M = 31.66, SD = 11.86; 55% Male; 80% White; 46% single/never married; 31% U.S.; 27% U.K.) were recruited from Prolific Academic™, a recruitment platform demonstrated to provide quality online data (Peer, Brandimarte, Samat, & Acquisti, 2017). On February 12, 2020, participants completed measures of personality, social connection, subjective well-being, and demographics (along with measures unrelated to this project) in return for $3.75 USD. As in Study 1, Time$_1$ data were collected prior to our pre-registration, but we created the pre-registration prior to obtaining our Time$_2$ data.

Time$_2$
From April 1–8, 2020, we invited the same Prolific users who had completed Time$_1$ measures to participate again in our Time$_2$ survey for $3.75 USD. This online survey included measures of the same constructs assessed at Time$_1$, as well as exploratory measures about participants' experiences during COVID-19. Our final sample comprised 336 participants (age: M = 32.03, SD = 11.94; 55% Male; 80% White; 45% single/never married; 32% U.S.; 27% U.K.) who completed both our Time$_1$ and Time$_2$ surveys and met our pre-registered inclusion criteria. This sample size gave us 80% power to detect effects of at least d = .15. Our dataset for this final sample is available on the OSF at https://tinyurl.com/yb337gsp.

Measures
The following measures are available on the OSF at https://tinyurl.com/yatuz9vu.

Social Connection
Social connection was assessed with two measures: (1) the 6-item relatedness subscale of the Balanced Measure of Psychological Needs (BMPN; Sheldon & Hilpert, 2012) and (2) the 20-item UCLA Loneliness Scale (Russell et al., 1980). At both Time$_1$ (α = .75) and Time$_2$ (α = .76), the relatedness subscale asked participants to think about the past week

and rate agreement with statements such as "I felt close and connected with other people who are important to me" (1 = *strongly disagree*, 7 = *strongly agree*). At both Time$_1$ (α = .95) and Time$_2$ (α = .95), the UCLA Loneliness Scale asked participants to respond to statements based on how they feel in general (e.g. "People are around me but not with me"; 1 = *never*, 4 = *often*). As pre-registered, we removed one item ("I am an outgoing person") because of its overlap with one of the BFI-2 extraversion items ("I am someone who is… outgoing, sociable").

Life Satisfaction
Participants also completed the 5-item Satisfaction With Life Scale (SWLS; Diener, Emmons, Larsen, & Griffin, 1985), judging their agreement in general with items such as "I am satisfied with my life" (1 = *strongly disagree*, 7 = *strongly agree*). SWLS scores were highly reliable (α = .92) at both timepoints.

Extraversion
At Time$_1$, participants completed the full 60-item BFI-2 (Soto & John, 2017), including a 12-item measure of extraversion (α = .88). For exploratory purposes, participants completed the same measure of extraversion at Time$_2$, which was highly correlated (r = .89) with their Time$_1$ extraversion score. No significant difference emerged between extraversion scores at Time$_1$ (M = 3.90; SD = 0.79) and Time$_2$ (M = 3.86, SD = 1.09), t(335) = −1.40, p = .162.

Physical distancing
The same measures of distancing were used as in Study 1.

Additional Exclusion Criteria
Per typical lab practice, to screen out inattentive participants, we excluded those who provided the same answer 15 times in a row on either the 20-item UCLA Loneliness Scale or the 24-item BFI, as pre-registered. We planned to use similar rules for missing data as in Study 1, but we did not have any missing data.

Study 2 Results
Similar to Study 1, 92.9% of participants reported practicing physical/social distancing, and the modal person indicated that no one got within 6 feet of them

the day before (*Mode* = 0, M = 1.11, SD = 0.75). Physical distancing statistics for countries with at least 15 participants can be found in Table S2 in Supplemental Material. The R code used for the following analyses is available on the OSF at https://tinyurl.com/ycutj4q5.

Has social connection changed as a result of the COVID-19 pandemic?
Pre-Registered Analyses
Using a paired-sample *t*-test, we found no differences between participants' reports of relatedness prior to the pandemic (Time$_1$: M = 4.90, SD = 1.11) versus during the pandemic (Time$_2$: M = 4.91, SD = 1.15), t(335) = −0.18, p = .857, d = 0.01, 95% CI = [−0.14, 0.16] (see **Figure 2**). However, participants reported feeling a little less lonely during the pandemic (Time$_2$: M = 2.07, SD = 0.63) than before (Time$_1$: M = 2.14, SD = 0.67), t(335) = −2.63, p = .009, d = 0.12, 95% CI = [−.03, 0.27] (see **Figure 2**). Correlations between our variables at both Time$_1$ and Time$_2$ are displayed in **Table 3**.

Has social connection changed more for extraverts or introverts?
Pre-Registered Analyses
Consistent with Study 1, we examined whether extraversion was linked to Time$_2$ connection after controlling for Time$_1$ connection. Extraversion was not associated with either Time$_2$ relatedness, b = 0.11, 95% CI = [−0.03, 0.26], p = .122 (after controlling for Time$_1$ relatedness; see **Table 4**, Model 1) or with Time$_2$ loneliness, b = 0.01, 95% CI = [−0.05, 0.07], p = .707 (after controlling for Time$_1$ loneliness; see **Table 4**, Model 2).

Exploratory Analyses
As in Study 1, we again entered extraversion into a regression model predicting change in our two social connection measures. With this approach, extraversion was not related to change in relatedness, b = −0.12, 95% CI = [−0.27, 0.03], p = .124 (see **Table 4**, Model 3), but higher levels of extraversion were linked to smaller decreases in loneliness, b = 0.11, 95% CI = [0.06, 0.17], p < .001 (see **Table 4**, Model 4). To further investigate this finding, we again subdivided our sample to focus on participants in the top and bottom quartiles for extraversion. Whereas
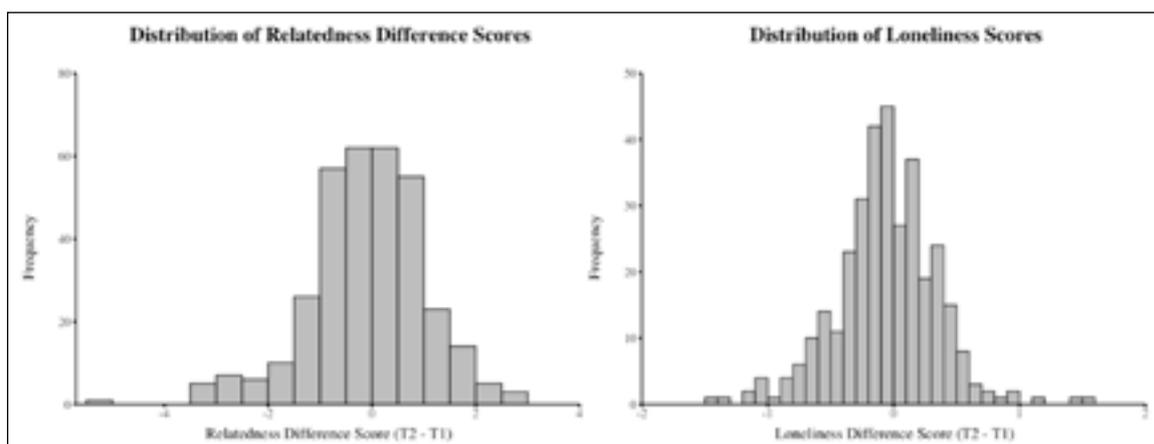

Figure 2: Distribution of relatedness and loneliness difference scores (Study 2).

Table 3: Correlations Among Variables for Time 1 and Time 2 (Study 2).

	T1 Life satisfaction	T2 Life satisfaction	Life Satisfaction change (T2–T1)	T1 Relatedness	T2 Relatedness	Relatedness change (T2–T1)	T1 Loneliness	T2 Loneliness	Loneliness change (T2–T1)	T1 Extraversion
T1 Life satisfaction	1									
T2 Life satisfaction	.83	1								
Life Satisfaction change (T2–T1)	–.37	.22	1							
T1 Relatedness	.51	.45	–.14	1						
T2 Relatedness	.35	.42	.09	.50	1					
Relatedness change (T2–T1)	–.13	–.004	.22	–.46	.54	1				
T1 Loneliness	–.56	–.55	.07	–.69	–.48	.19	1			
T2 Loneliness	–.46	–.55	–.11	–.58	–.65	–.10	.80	1		
Loneliness change (T2–T1)	.20	.03	–.29	.22	–.24	–.46	–.38	.24	1	
T1 Extraversion	.40	.40	–.02	.34	.24	–.08	–.54	–.42	.22	1
Mean (SD)	3.97 (1.53)	3.99 (1.45)	0.02 (0.88)	4.92 (1.09)	4.91 (1.14)	–0.01 (1.11)	2.12 (0.65)	2.06 (0.62)	–0.06 (0.40)	3.90 (0.79)

Table 4: Results of Multiple Regression Models (Study 2).

Dependent Variable and Predictors	df	Adjusted R^2	b(SE)	95% CI	β	t	p
Time 2 relatedness (Model 1)[a]	333	.254					
Time 1 relatedness			0.50 (0.05)	[0.40, 0.61]	0.48	9.509	<.001
Extraversion			0.11 (0.07)	[−0.03, 0.26]	0.08	1.55	.122
Time 2 loneliness (Model 2)[a]	333	.642					
Time 1 loneliness			0.77 (0.04)	[0.70, 0.84]	0.81	20.835	<.001
Extraversion			0.01 (0.03)	[−0.05, 0.07]	0.01	0.376	.707
Relatedness difference score (T2–T1; Model 3)[b]	334	.004					
Extraversion			−0.12 (0.08)	[−0.27, 0.03]	−0.08	−1.542	.124
Loneliness difference score (T2–T1; Model 4)[b]	334	.047					
Extraversion			0.11 (0.027)	[0.06, 0.17]	0.22	4.183	<.001
Satisfaction with life difference score (T2–T1; Model 5)[a]	332	.042					
Relatedness difference score (T2–T1)			0.13 (0.19)	[−0.25, 0.51]	0.16	0.674	.501
Extraversion			−0.001 (0.06)	[0.06, 0.30]	−.001	−0.024	.981
Extraversion × Relatedness difference score			0.01 (0.05)	[−0.08, 0.09]	.06	0.248	.804
Satisfaction with life difference score (T2–T1; Model 6)[a]	331	.182					
Relatedness difference score (T2–T1)			0.13 (0.18)	[−0.23, 0.48]	0.16	0.711	.478
Extraversion			0.18 (0.06)	[0.06, 0.30]	0.16	2.941	.004
Time 1 Satisfaction with life			−0.24 (0.03)	[−0.30, −0.18]	−0.41	−7.609	<.001
Extraversion × Relatedness difference score			0.004 (0.04)	[−0.08, 0.09]	0.02	0.099	.921
Satisfaction with life difference score (T2–T1; Model 7)[a]	332	.079					
Loneliness difference score (T2–T1)			−0.89 (0.50)	[−1.88, 0.10]	−0.41	−1.777	.076
Extraversion			0.06 (0.06)	[−0.06, 0.18]	0.05	0.924	.356
Extraversion × Loneliness difference score			0.06 (0.13)	[−0.19, 0.32]	0.11	0.470	.638
Satisfaction with life difference score (T2–T1; Model 8)[a]	331	.212					
Loneliness difference score (T2–T1)			−0.93 (0.47)	[−1.84, −0.01]	−0.42	−1.997	.047
Extraversion			0.22 (0.06)	[0.11, 0.34]	0.20	0.060	<.001
Time 1 Satisfaction with life			−0.23 (0.03)	[−0.29, −0.17]	−0.40	−7.552	<.001
Extraversion × Loneliness difference score			0.10 (0.12)	[−.14, .33]	0.17	0.814	.416

Note: [a] pre-registered analysis; [b] exploratory analysis.

our most extraverted participants showed no change in loneliness from Time$_1$ ($M = 1.64$, $SD = 0.51$) to Time$_2$ ($M = 1.67$, $SD = 0.49$), $t(82) = −1.09$, $p = .279$, $d = 0.07$, 95% CI = [−0.23, 0.38], our most introverted participants decreased in loneliness from Time$_1$ ($M = 2.56$, $SD = 0.63$) to Time$_2$ ($M = 2.31$, $SD = 0.63$), $t(79) = 4.02$, $p < .001$, $d = 0.39$, 95% CI = [.07, .70]. Interestingly, this pattern of results mirrors those of Study 1 with a different measure of social connection: Introverts appear to have fared better than extraverts during the pandemic compared to before the pandemic, but this difference is accounted for by the relatively higher initial levels of loneliness reported by introverts before the pandemic (see **Figure 3**).

Is the effect of change in social connection on well-being different for extraverts and introverts?
Pre-Registered Analyses
We used the same set of pre-registered analyses as in Study 1 to test whether changes in social connection had a relatively larger effect on well-being for extraverts. The Extraversion × Change in Relatedness interaction was not a significant predictor of changes in life satisfaction (see **Table 4**, Model 5), and this finding remained unchanged after we controlled for Time$_1$ life satisfaction (see **Table 4**, Model 6). With loneliness in the model instead of relatedness, the Extraversion × Change in Loneliness interaction was similarly nonsignificant (see **Table 4**, Model 7), even after controlling for Time$_1$ life satisfaction
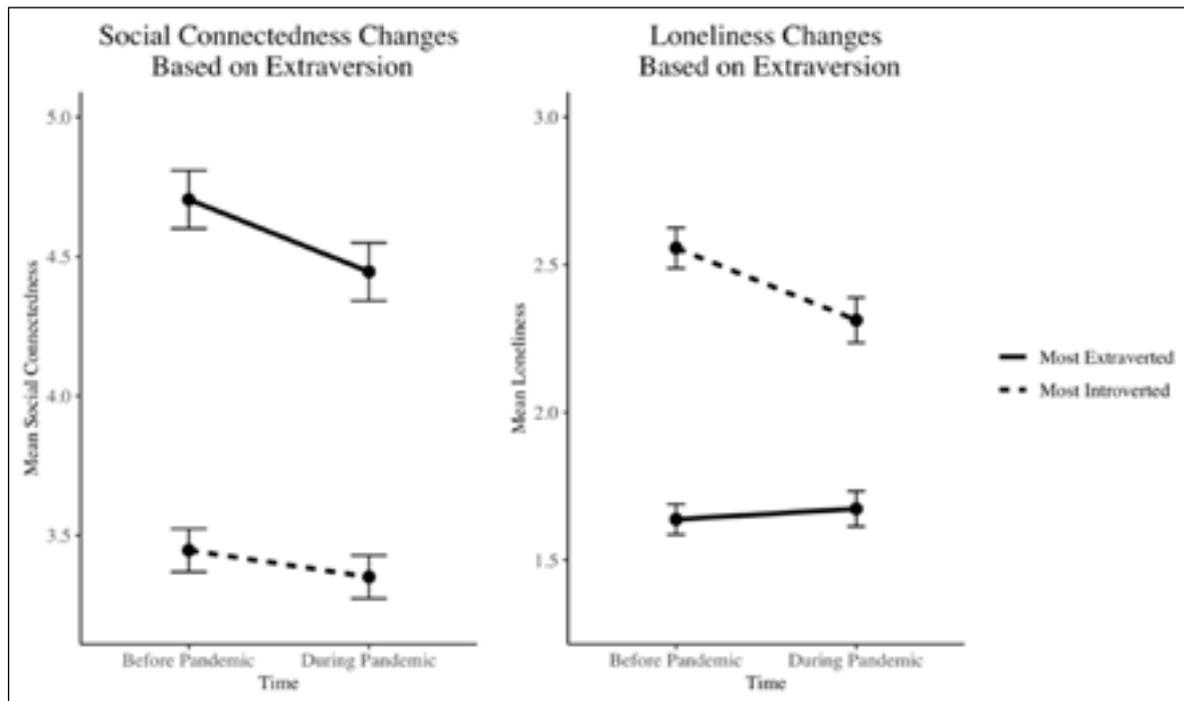
Figure 3: Changes in social connectedness and loneliness for the most introverted and extraverted participants (Study 1 and Study 2; 95% CI error bars).

(see **Table 4**, Model 8). See Table S1, Models S1 and S2 in Supplemental Material for alternative modeling approaches to Model 6 and Model 8.

Exploratory Analyses

A paired-sample t-test showed that life satisfaction did not change from $Time_1$ ($M = 3.96$, $SD = 1.56$) to $Time_2$ ($M = 3.98$, $SD = 1.46$); $t(335) = -0.43$, $p = .666$, $d = 0.02$, 95% CI = $[-.13, .17]$. Increases in relatedness were associated with increases in life satisfaction, $r(334) = .22$, $p < .001$, and increases in loneliness were associated with decreases in life satisfaction, $r(334) = -.29$, $p < .001$.

Study 2 Discussion

In Study 2, participants exhibited no change in relatedness and a small but significant decrease in loneliness during the COVID-19 pandemic (vs. before the pandemic). Our exploratory analyses revealed that our most introverted participants showed a significant improvement in loneliness, whereas our most extraverted participants showed no improvement in loneliness. However, when we controlled for loneliness levels prior to the pandemic (as pre-registered), we found no significant relationship between extraversion and loneliness during the pandemic. Finally, for introverts and extraverts alike, shifts in relatedness and loneliness were linked to corresponding changes in life satisfaction.

General Discussion

In two pre-registered studies, we tracked changes in social connection during a time period characterized by the most momentous changes in social behavior that many people have experienced in their lifetimes.

Given that physical distancing guidelines compelled individuals to stay at least 6 feet from almost everyone, it would be reasonable to expect considerable declines in social connection. Yet, in Study 1, university students exhibited only small drops in social connectedness during the COVID-19 pandemic, relative to their own levels of connectedness in the months preceding the pandemic. Similarly, in Study 2, a diverse sample of adults showed no significant shifts in relatedness and actually reported improvements in loneliness. Taken together, our findings suggest that people experienced relatively little change in feelings of social connection, on average, in the face of the initial reshaping of their social lives caused by the COVID-19 pandemic.

At first glance, our exploratory results lend credence to the popular notion that extraverts have fared worse than introverts. In Study 1, extraverts showed larger declines in social connectedness than introverts. Conversely, in Study 2, introverts showed larger improvements in loneliness than extraverts. As our pre-registered analyses revealed, however, the effect of extraversion on change in social connection reversed (Study 1) or disappeared (Study 2) when we controlled for initial levels of social connection prior to the pandemic. In essence, extraverts appear to have lost more only because they had more to lose. Analogously, a study that compared the effectiveness of a low-carb diet for sumo wrestlers and ice skaters would likely find that the diet produced more weight loss for the wrestlers than the skaters. However, this apparent difference in the effectiveness of the diet might disappear after controlling for the athletes' pre-diet weights. That is, a wrestler and a skater who began the study at the same weight would be expected to lose the same amount. Similarly, our results

suggest that an extravert and an introvert who began with similar levels of social connection would be expected to show similar declines in connection during COVID-19. But just as wrestlers and skaters seldom weigh the same, highly extraverted and highly introverted individuals seldom feel equally socially connected. Thus, the popular advice to "check on your extraverted friends" during the quarantine may not be entirely misguided, in that the most extraverted individuals in our sample did indeed exhibit the biggest drops in feelings of social connection.

Regardless of extraversion, college students who experienced larger declines in social connectedness also reported larger increases in lethargy (Study 1), and adults who experienced greater increases in loneliness or decreases in relatedness reported larger declines in life satisfaction (Study 2). Overall, during the pandemic, participants reported a substantial increase in momentary feelings of lethargy (Study 1) but no change in overall life satisfaction (Study 2).

Due to the differences between our two samples, there was likely substantial variability in participants' experiences during the pandemic. By the beginning of April 2020, British Columbia had declared a public health emergency, and strict physical distancing guidelines were in place (CBC, 2020). Furthermore, classes at UBC were moved online on March 13th (UBC, 2020); thus, by early April, students had already engaged in the relatively solitary process of online learning for 3 weeks. Similar, but more variable restrictions were in place across the United States, with California issuing stay at home orders on March 19th while other states such as South Carolina did not issue similar formal orders until April 7th (Mervosh et al., 2020). In the United Kingdom, by April 1st, citizens were unable to leave their homes "without reasonable excuse"—reasons such as grocery shopping, exercise, and other necessary activities (BBC, 2020). Despite the variability in restrictions, the vast majority of participants in both studies reported physical distancing; looking at the five countries with at least 15 participants in Study 2, we saw the lowest levels of physical distancing in Poland (79%), while 100% of participants from Portugal and Canada reported physical distancing (see Supplemental Material, Table S2). In both studies, most participants also reported not getting within 6 feet of anyone outside their own household on the preceding day, suggesting that our participants interacted with substantially fewer people during the pandemic than before.

Thus, the most surprising finding from our research was that participants' sense of social connection remained largely intact. This pattern is consistent with the idea of substitution, that human beings will find alternative ways to satisfy their fundamental need to belong when previous sources of connection become unavailable (Baumeister & Leary, 1995). Although these findings should be treated with caution, our results offer a hopeful message that people can uncover opportunities for connection and social bonding, even in a time of upheaval. That said, a segment of individuals in each study did experience substantial declines in social connection. In Study 1, for example, 10% of participants showed more than a full point loss in connectedness. Our findings, then, are not at odds with anecdotal reports of individuals experiencing severe loneliness during the pandemic (e.g., Bruni, 2020), but our research does suggest that most people remained reasonably connected during the first phase of COVID-19.

Constraints on Generality
Care is needed in generalizing the findings of the present research. In particular, it is worth noting that individuals who experienced especially severe upheavals as a result of the pandemic (e.g., developing COVID-19 themselves) may have been less likely to participate in our studies. However, in Study 2, 87% of participants who completed our Time 1 survey before the pandemic also completed our survey during the pandemic, suggesting that our sample did not consist only of a highly self-selected set of people who were doing unusually well. Of course, neither of our studies included nationally representative samples, limiting generalizability. This important limitation is mitigated somewhat by the fact that our results were broadly consistent across two very different samples—students enrolled at a university in British Columbia, Canada (Study 1) and adults drawn from the U.S., U.K., and 26 other countries (Study 2). Finally, because we assessed social connection within a few weeks of the introduction of physical distancing measures in North America and Europe, our results only capture people's relatively immediate psychological responses. It is possible that despite the negative effects of physical distancing, people's tendency for increased social engagement in the immediate aftermath of collective trauma was still buffering them somewhat from experiencing large drops in feelings of connection (Cohn et al., 2004; Pennebaker & Harber, 1993). As such, if these restrictions were continued or reinstated, people might experience growing costs in terms of social connection.

Future Directions
Future research should investigate the mechanisms behind the resilience documented in the present study. If a second wave of COVID-19 were to occur, researchers could conduct daily diary studies with finer-grained measures of behavior (e.g., duration and frequency of online interactions) to examine psychologically protective behaviors in the face of the pandemic. Furthermore, researchers should explore which public health restrictions (e.g., school closures, restaurant/bar closures) are most detrimental to well-being. When we conducted our research, a slew of restrictions had already been put in place. However, as restrictions are pulled back and then potentially reinstated, researchers will be able to examine the relative impact of certain restrictions on social connection compared to others. In all of these cases, investigators would benefit from taking advantage of pre-COVID-19 baseline measures by following up with participants who previously completed relevant measures as part of other studies. Overall, our two studies offer a snapshot of the psychological consequences of the initial COVID-19 pandemic, but future research will be required

to offer a fuller portrait of how the fundamental human need for connection will continue to be tested by this unprecedented global social experiment.

Data Accessibility Statement

Data, materials, and R code for Study 1 and Study 2 can be found on the OSF at https://tinyurl.com/ycx4jtn9 (Study 1) and https://tinyurl.com/ydgqxyqe (Study 2).

Notes

[1] We conceptualize extraversion as a continuous dimension but refer to individuals relatively high in extraversion as "extraverts" and relatively low in extraversion as "introverts" as shorthand, consistent with Srivastava and colleagues (2008).

[2] At Time$_2$ only, participants completed the Scale of Positive and Negative Experiences (SPANE; Diener et al., 2009; α = .90) for exploratory purposes. Participants indicated how much they experienced feelings such as "pleasant" and "sad" over the prior 7 days (1 = *very rarely or never*, 5 = *very often or always*). Lethargy at Time$_2$ was strongly correlated with experiencing negative emotions, $r(465) = .54$, $p < .001$, and positive emotions, $r(465) = -.47$, $p < .001$.

[3] All *d's* reported were calculated using pooled standard deviation and their corresponding CI's do not account for the paired-samples design.

Additional Files

The additional files for this article can be found as follows:

- **Table S1.** Results of Multiple Regression Models (Study 1 and Study 2). DOI: https://doi.org/10.1525/collabra.365.s1
- **Table S2.** Physical Distancing by Country (Study 2). DOI: https://doi.org/10.1525/collabra.365.s2

Competing Interests

The authors have no competing interests to declare.

Author Contributions

- Contributed to conception and design: All authors
- Contributed to acquisition of data: All authors
- Contributed to analysis and interpretation of data: All authors
- Drafted and/or revised the article: All authors
- Approved the submitted version for publication: All authors

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