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Extraverts suffer from social distancing: A 30-day diary study☆

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ABSTRACT

Public health emergencies such as the coronavirus disease 2019 (COVID-19) pandemic force policymakers to implement appropriate measures including social distancing to curb the spread of the virus. Although most people assume that such measures impact mental health, the extent of the impact may vary considerably between individuals. Using data from a 30-day diary study that captured daily happiness ratings (N = 611; 15,607 observations) during the worst wave of the COVID-19 pandemic in Hong Kong, we used multi-level modeling to test whether the Big Five personality factors moderated the relationship between enforced social distancing and happiness. We observed that people's happiness was stable throughout the enforcement and easing of social distancing. During the study period, both extraversion and agreeableness were found to be positively associated with happiness. Those high in extraversion were less happy when the distancing measures were enforced than when they were lifted. Our findings point to extraversion as a risk factor in public health emergencies and the importance of identifying people at risk to ensure immediate intervention during a pandemic.

1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic (the pandemic) is considered the most severe worldwide pandemic in the last 100 years (Gates, 2020). Throughout the pandemic, policymakers struggled to balance the economic and mental health costs of the crisis when developing public health policies (Layard et al., 2020). As the world moves beyond the pandemic, research continues to offer grim reminders of its economic impact. For example, Walmsley et al. (2021) estimated a 23% net cost on the United States' gross domestic product. However, the cost to mental health is yet to be thoroughly evaluated. To assess the mental health cost of social distancing, the present study assessed people's happiness during the pandemic and the effects of the Big Five personality factors in moderating the relationship between social distancing and 30 days of happiness scores.

1.1. The emotional cost of social distancing

Studies worldwide have provided evidence of the detrimental effects of the pandemic on emotions (Carel et al., 2020; Holt-Lunstad & Uchino, 2015). Residents in Italy reported sadness, fear, anxiety, and anger during their lockdown periods (Cerbara et al., 2020). In Australia, people in lockdown had more low-arousal negative emotions (e.g., sadness) than those who were not locked down (Moeck et al., 2023). Social distancing was associated with worsened mood in the United States (Ford, 2021; Marinucci et al., 2022) and Hong Kong (Hou et al., 2021; Wong et al., 2022). Sentiment analysis of Twitter posts by Hong Kong residents revealed a decline in valence scores during the early months of the pandemic in 2020, although valence scores rose in subsequent months (Chen, 2022). Similar results were obtained in Chen and Yik's (2022) analysis of Weibo posts during the Wuhan lockdown in China (Gutiérrez-Cobo et al., 2021; Su et al., 2021). In a study of 33 countries, Reitsema et al. (2022) observed that people reported both positive and negative emotions in response to social distancing measures.

Although the pandemic appeared to affect people's emotions, the results are far from conclusive. The pandemic's "impact", which may be attributable to mandatory testing, working from home, academic

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adjustments for students, and enforced social distancing measures, has been loosely defined and mostly equated with "social distancing" in past research (Ammar et al., 2020 is an exception). The present study specifically tested the impact of the ongoing, daily impact of social distancing on Hong Kong residents' happiness during the period when the city was transitioning out of the strictest pandemic restrictions. We specifically assessed whether the lifting of social distancing measures enhanced or lowered happiness. Our study represents a natural experiment that measures the effects of social distancing measures on daily happiness levels (Leatherdale, 2019).[1]

1.2. Personality and happiness

Much of what psychologists mean by "personality" can be succinctly summarized by the five-factor model of personality (McCrae & John, 1992). The "Big Five" factors are neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness. Meta-analyses have reported their robust relationships with life satisfaction (Anglim et al., 2020) and physical and mental health (Strickhouser et al., 2017), highlighting their potential to facilitate the understanding of people's emotional changes in response to social distancing.

During the pandemic, a plethora of studies on the relationship between emotions and personality was generated. Neuroticism was the strongest predictor of loneliness, stress, and depression (Ikizer et al., 2022; Morstead et al., 2022), whereas extraversion was associated with positive and negative affect (Anglim & Horwood, 2021; Lacko et al., 2023; Morales-Vives et al., 2020). Neuroticism was positively associated with health anxiety, general anxiety, and depressive symptoms, whereas extraversion, agreeableness, and conscientiousness were negatively associated with health anxiety (Morstead et al., 2022; Nikčević et al., 2021). However, studies on how the Big Five factors moderate the effect of social distancing on emotions—a topic of major concern to policymakers—are lacking. For example, extraverts, who are characterized as being sociable, active, and impulsive, may have been particularly impacted emotionally by distancing measures that physically confined them to their homes. The current study examined the interaction effects between the Big Five personality factors and social distancing on a 30-day trajectory of happiness.

2. Method

2.1. Data collection and participants

Data for the analyses were from a 30-day diary study conducted from 29 March to 4 May 2022. Of the 764 participants recruited from a university in Hong Kong using mass invitation emails,[2] 708 resided in Hong Kong at the time of recruitment. Ultimately, 611 participants (46% female) were included in the final dataset because they had completed questionnaires in the pre-diary and post-diary sessions and at least one day of questionnaires during the diary session.[3] The retention rate of 86% (of the 708 participants) was similar to that of other diary studies (Vachon et al., 2019). On average, the participants completed 25.5 days (range = 5 to 30 days), indicating a high compliance rate that was within the compliance range of other experience-sampling studies (Wilt & Revelle, 2019).[4]

2.2. Procedure

Data collection was through surveys on surveyYIK, an app developed by the first author for use on Android and iOS devices. The study included three sessions. In the pre-diary session, participants were required to provide informed consent before responding to several questionnaires and demographic questions within a week. On the day after they completed the pre-diary surveys, the participants began a 30-day diary session during which they received a daily pop-up notification on their smartphones at 8:00 pm that reminded them to answer the question "Compared with an average Hong Kong University of Science and Technology (HKUST) student, how happy were you today?" using a 5-point rating scale ranging from 1 (*very unhappy*) to 5 (*very happy*). In the third (post-diary) session, which began after the completion of the diary session, participants were asked to complete several questionnaires including the NEO Five-Factor Inventory 3 (FFI-3; McCrae & Costa, 2010; Yik et al., 2023) within one week. The study protocol was approved by the Human and Artefacts Research Ethics Committee of the HKUST. Appendix A includes details of the three sessions.

2.3. Measures

2.3.1. Social distancing

The severity of societal restrictions was measured using the stringency index (SI) of the Oxford Government Response Tracker (Hale et al., 2021), an assessment tool that aggregates the degrees of strictness of global policies that restrict behaviors under social distancing or lockdown protocols. The SI ranges from 0 (*no restrictions*) to 100 (*complete lockdown*).

2.3.2. NEO Five-Factor Inventory 3 (FFI-3)

We included 60 items from the self-report measure (Form S) of the FFI-3 to measure neuroticism (N), extraversion (E), openness to experience (O), agreeableness (A), and conscientiousness (C). The participants reported how much they agreed with each item on a 5-point rating scale that ranged from 0 (*strongly disagree*) to 4 (*strongly agree*). The Cronbach's alphas were 0.79 (N), 0.74 (E), 0.69 (O), 0.68 (A), and 0.81 (C).

2.3.3. Satisfaction with Life Scale (SWLS)

The study participants indicated the extent of their agreement with each of the five statements (e.g., "In most ways, my life is close to my ideal") in the SWLS (Diener et al., 1985) on a 7-point scale that ranged from 1 (*strongly disagree*) to 7 (*strongly agree*). The five ratings were then averaged, with high values indicating high satisfaction with life. The Cronbach's alpha for the scale was 0.84.

2.3.4. Covariates

Age, sex, and SWLS were included in the analyses given their documented associations with the study variables (Chen & Yik, 2022; Weber et al., 2015). Weekends and public holidays were also included as covariates.

2.4. Analytic strategy

Given that the dataset had a hierarchical data structure in which repeated measures of happiness were nested within each participant, multilevel modeling was deemed suitable for the statistical analysis

[1] The study period (29 March to 4 May 2022) provided an ideal platform on which to test the effects of enforced social distancing on happiness given that Hong Kong experienced the strictest enforcement and subsequent easing of social distancing during this period.

[2] Given the time-sensitive nature of the data collection, the study's sample size was based on recruiting the maximum possible number of participants over the specified period.

[3] Incorporating data points from participants who did not complete all of the 30 days reduces concerns about the effect of participant attrition over time (Myin-Geremeys & Kuppens, 2022).

[4] Those who completed the questionnaires in the pre- and post-diary sessions and 70% of the diary sessions received a cash incentive of HK$150 (equivalent to US$20).

(Lafit et al., 2021). We grand-mean centered the personality factors for within- and between-person analyses. Social distancing, sex, public holidays, and weekends were dummy coded. A code of 0 was used for the period during which social distancing was lifted and 1 for the period during which social distancing was enforced. Social distancing measures were eased on 21 April 2022 in Hong Kong; on that date, the SI of the Oxford Government Response Tracker decreased from 71 to 60. Males and females were coded with 0 and 1, respectively, whereas non-statutory holidays were coded with 0 and public holidays (Tomb Sweeping Day on 5 April 2022; Easter holidays from 15 to 18 April 2022) with 1. Weekdays and weekends were coded as 0 and 1, respectively. Appendix B includes the model specifications.

3. Results

Fig. 1 shows the daily mean happiness levels and the number of new COVID-19 cases during the periods of enforcement and lifting of social distancing measures over the study period. The happiness levels (all above 2.95 out of 5) were stable across the 37 days and the two social distancing periods. The happiness levels did not rise with the decline in the number of new COVID-19 cases and did not fluctuate between the two periods.

Table 1 shows the univariate and bivariate statistics for the study variables and covariates. The mean happiness score was positively correlated with extraversion, openness to experience, agreeableness, and conscientiousness and negatively correlated with neuroticism. SWLS was significantly correlated with happiness and all five personality factors.

To assess the proportion of happiness variance attributable to the between- versus within-person levels, an empty multilevel model with a random intercept was fitted to the data (Snijders & Bosker, 2011). The results indicated a significant between-person variance (F [27, 811] = 14.6, $p < .001$). The intraclass correlation coefficient was 0.31 (95% confidence interval: [0.21, 0.47]), implying that between-person fluctuations accounted for 31% of the variance in happiness. These results justified the multilevel analysis at both levels 1 (within-person) and 2 (between-person).

To test the relationships among the 30-day happiness trajectory,

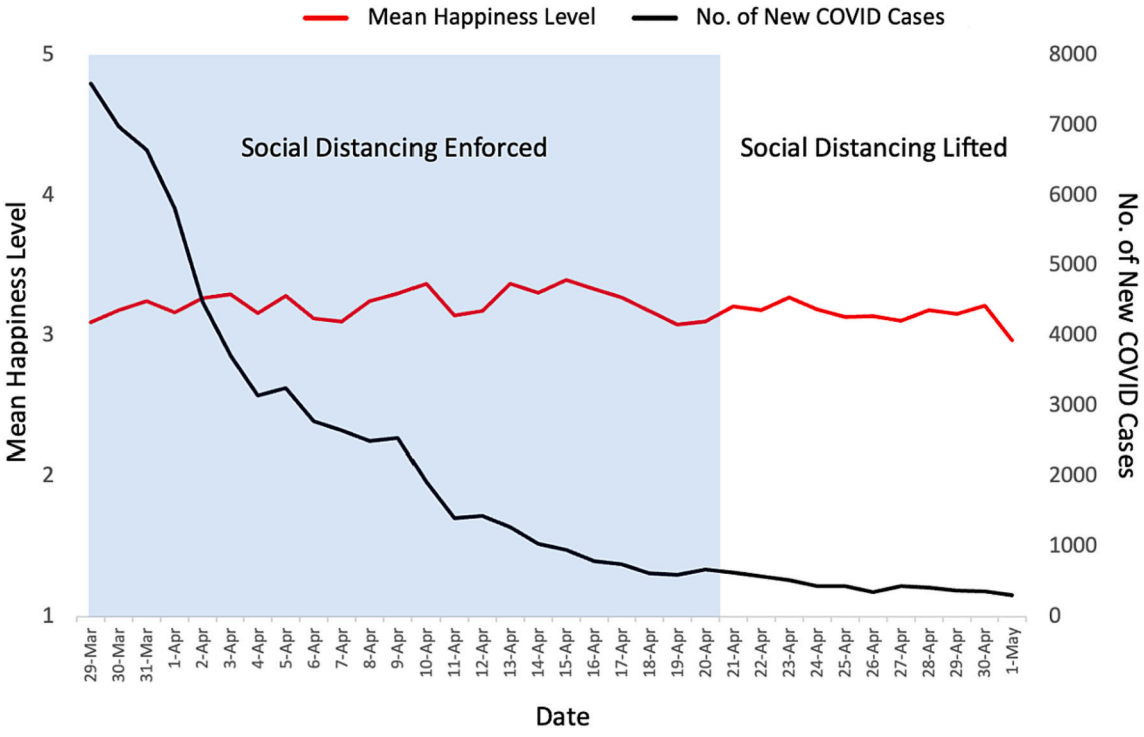

Fig. 1. Daily happiness level during the COVID-19 pandemic (29 March–4 May 2022; $N = 611$). Note: Possible mean happiness scores ranged from 1 to 5; actual scores ranged from 2.96 to 3.40. The graph displays the mean happiness level for a given date when at least 11 data points were available.

Table 1
Descriptive statistics of the study variables and covariates ($N = 611$).

Variable	*M*	*SD*	Correlations						
			1	2	3	4	5	6	7
1. Happiness	3.22	0.54							
2. N	28.65	6.51	**−0.210**						
3. E	24.63	5.81	**0.263**	**−0.232**					
4. O	28.32	5.55	**0.251**	0.029	**0.173**				
5. A	28.19	5.51	**0.149**	0.022	.065	**0.284**			
6. C	27.19	6.25	**0.240**	**−0.300**	**0.312**	**0.101**	**0.146**		
7. Age	20.31	1.80	**0.096**	**−0.082**	0.042	0.042	0.004	**0.110**	
8. SWLS	3.88	1.17	**0.434**	**−0.356**	**0.259**	**0.127**	**0.112**	**0.288**	−0.047

Note: Happiness = mean happiness score; N = neuroticism; E = extraversion; O = openness to experience; A = agreeableness; C = conscientiousness; SWLS = satisfaction with life scale. Possible scores were 1 to 5 for happiness; 0 to 48 for each of N, E, O, A, and C; and 1 to 7 for SWLS. Correlations greater than the absolute value of .065 were significant at $p < .05$ and are presented in bold.

Table 2
Modeling the 30-days-of-happiness scores on social distancing and the Big Five personality factors.

Effects		Happiness level, *b* (*SE*)		
		Empty model	Main effects model	Interaction model
Fixed effects				
Intercept	γ_0	3.214 (0.017)***	3.198 (0.032)***	2.602 (0.042)***
N	γ_1		−0.004 (0.001)***	−0.003 (0.003)
E	γ_2		0.010 (0.001)***	0.017 (0.003)***
O	γ_3		0.016 (0.001)***	0.016 (0.003)
A	γ_4		0.005 (0.001)***	0.001 (0.003)***
C	γ_5		0.005 (0.001)***	0.006 (0.003)
Social distancing	γ_6		0.038 (0.035)	0.037 (0.035)
Holiday	γ_7		0.073 (0.039)	0.073 (0.039)
Weekend	γ_8		0.095 (0.032)**	0.095 (0.032)**
SWLS	γ_9		0.154 (0.007)***	0.154 (0.007)***
Age	γ_{10}		0.030 (0.004)***	0.030 (0.004)***
Sex	γ_{11}		−0.107 (0.015)***	−0.107 (0.015)***
Social distancing*N	γ_{12}			−0.001 (0.003)
Social distancing*E	γ_{13}			−0.009 (0.003)**
Social distancing*O	γ_{14}			−0.000 (0.003)
Social distancing*A	γ_{15}			0.004 (0.003)
Social distancing*C	γ_{16}			−0.001 (0.003)
Random effects				
LRT, χ^2(df)		65.43(1)***	37.75 (1)***	37.66 (1)***
Residual variance	σ^2	0.892	0.816	0.815
Variance	τ^2	0.007	0.004	0.004
Goodness of fit				
AIC		41,122.00	39,847.00	39,895.00
BIC		41,081.23	39,918.35	40,004.47

Note: N = neuroticism; E = extraversion; O = openness to experience; A = agreeableness; C = conscientiousness; SWL = satisfaction with life scale; AIC = Akaike information criterion; BIC = Bayesian information criterion. Standard errors are in parentheses. All models were fit using a likelihood ratio test (LRT) estimation. In the main effects and interaction models, the slopes of the predictor variables were free to vary. The Big Five personality factors were grand-mean centered. *$p < .05$; **$p < .01$; ***$p < .001$.

social distancing, and personality, we fitted the main effects model to the data using the daily happiness score as the dependent variable and the personality factors as the independent variables. The results are summarized in Table 2. Although social distancing did not have a significant effect on happiness ($b = 0.038$, $p = .280$), we observed a significant random effect for days ($\chi^2(1) = 37.75$, $p < .001$), indicating that the happiness levels varied across the 30 days. All of the personality factors were associated with happiness. The participants who were high in extraversion, openness to experience, agreeableness, and conscientiousness reported higher levels of happiness over time, whereas those high in neuroticism reported lower levels of happiness over time.

Next, we tested the interaction effects between social distancing and personality on happiness, the results of which are shown in the last column of Table 2.[5] Of the five interaction terms, only extraversion*social distancing was statistically significant ($b = -0.009$, $p = .006$).[6] The main effects of extraversion and agreeableness remained significant after the interaction terms were introduced. Specifically, both extraversion and agreeableness were found to be positively associated with happiness over time, and extraversion had a stronger effect than agreeableness.

To further examine the significant interaction effects, a simple slope analysis was conducted. Fig. 2 displays the results. A positive association was observed between extraversion and happiness during the period without social distancing ($b = 0.02$, $t = 5.87$, $p < .001$) and the period with social distancing ($b = 0.01$, $t = 5.06$, $p < .001$), indicating that people who had a high score in extraversion were happy during both periods. However, because the coefficient during the lifting of social distancing measures was greater than that during the enforcement of measures ($0.02 > 0.01$), we concluded that people who were high in extraversion were less happy with than without social distancing.

4. Discussion

Hong Kong confirmed its first COVID-19 case on 22 January 2020, after which the city experienced multiple waves of mass infection. Beginning in late December 2021, the fifth wave (the focus of this study) introduced the strictest social distancing measures in the city. In an experience-sampling dataset that included 15,607 observations ($N = 611$) across 30 days during the fifth wave, we observed that social distancing had an overall non-significant effect on the study participants' happiness (see also Chen, 2022). Although people high in extraversion were happier than those low in extraversion, they were less happy when tight social distancing measures were enforced than when measures were lifted.

In contrast to studies that have indicated the far-reaching detrimental emotional costs of social distancing worldwide (Cerbara et al., 2020; Ford, 2021; Moeck et al., 2023), we observed that the daily happiness levels of the study participants remained constant throughout the study period regardless of the implementation of social distancing (see Chen & Yik, 2022; Pan et al., 2021). Although the results are confounding, we note that our study specifically examined the effects of physical social distancing, which might be counterbalanced by digital

[5] We tested the interaction model by taking out the covariate SWLS. Although the main effects of N, O, and C became significant, the main effects of E and A, and E*social distancing remained significant with improved *b*s. It is prudent to conclude that the effects reported in Table 2 were robust, regardless of the SWLS level.

[6] We tested another five interaction models each with only one of the five interaction terms and found a significant effect for E*social distancing only.

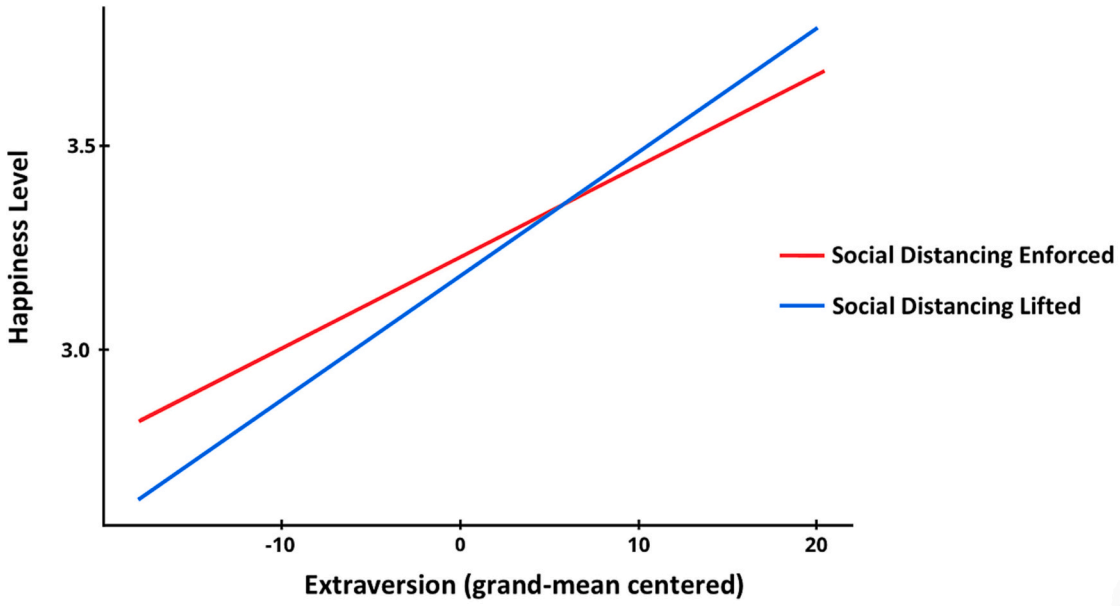

Fig. 2. Association between happiness level and social distancing moderated by extraversion. *Note*: Possible scores were 1 to 5 for the happiness level and 0 to 48 for extraversion.

social connections (Chen, 2022) without which worsened mental health has been observed (Holt-Lunstad & Uchino, 2015).

Hedonic adaptation may have affected the results on the stability of happiness levels during the study period. Humans are known to adapt to the worst tragedies (Bonanno et al., 2011). Hedonic adaptation describes the accommodation of emotional reactions to repeated situations over a period (Frederickson & Loewenstein, 1999). By the fifth wave, the study participants had already experienced over two years of the pandemic, which included several waves of social distancing. Furthermore, by the fifth wave, people may have turned their attention to other societal events such as the contraction of the COVID-19 virus by family members, the downturn in the economy, and job security (Chan et al., 2022; Rogers & Cruickshank, 2021). Therefore, the impact of the strictest social distancing may have been pushed to the psychological background (Kahneman & Thaler, 2006), thus resulting in minimal impact on happiness levels.

Overall, the happiness levels were not associated with the implementation of social distancing measures. The participants high in extraversion remained happy during periods of enforced social distancing, echoing prior findings that supported people's resilience under such measures (Lo et al., 2022; Naidu et al., 2022). However, they were less happy when social distancing was enforced than when it was eased. A defining feature of extraversion is a high reward sensitivity (Lucas et al., 2000). Reward sensitivity reflects Gray's (1970) behavioral activation system, which describes the regulation of people's reactions to signals of rewards and is associated with pleasant feelings (for biological evidence, see Sutton & Davidson, 1997). Characterized by a strong behavioral activation system (Depue & Collins, 1999; Yik, 2009; Yik et al., 2011), extraverts are exceptionally sensitive to rewards and engage in fun-seeking activities (Carver & White, 1994). When they were freed from their homes after social distancing measures were lifted, the face-to-face interactions they experienced provided much-needed opportunities to satisfy their need for rewards, thereby enhancing their happiness. To further the understanding of the role of extraversion in public health emergencies, researchers could examine behaviors sought by extraverts in everyday activities (Lucas & Diener, 2001) to assess whether they seek rewards and fun activities both online and in person.

5. Conclusion

Social distancing is considered a critical measure for containing the spread of virus infection during a pandemic. However, it is also a double-edged sword that forces policymakers worldwide to grapple with the trade-off between the physical and mental health of their citizens. Many reports to date have described the economic cost of the social distancing measures and lockdowns that were implemented during the pandemic. Our study was a natural experiment with a 30-day diary design that specifically tested the impact of social distancing on happiness during the period when Hong Kong was transitioning out of the worst wave of the pandemic. The participants were found to be resilient to social distancing measures, a result that contradicts previous findings. However, people who were high in extraversion suffered from social distancing, a result that calls for appropriate intervention for this group during the enforcement of future societal restrictions.

CRediT authorship contribution statement

Michelle Yik: Conceptualization, Methodology, Investigation, Writing - original draft preparation, reviewing and editing. **Nicolson Siu:** Formal analysis, Visualization, Writing – reviewing and editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Data collection sessions

Table A1
Data collection in the three sessions.

Session	Dates	Study day	Questionnaire
Pre-diary	28 March–4 April 2022	Day 0	SWLS; demographics
Daily diary	29 March–4 May 2022	Days 1–30	"How happy were you today?" survey
Post-diary	6 May–13 May 2022	Day 31	FFI-3

Note: SWLS = satisfaction with life scale. FFI-3 = NEO Five-Factor Inventory 3.

Appendix B. Model specifications

A multilevel model separates the residual variances of a sample into level 1 (within-person) and level 2 (between-person) variances. Multilevel modeling allows for data dependency and implies that the measures of one participant are more similar to one another than to the measures of another participant. In addition, not every participant provided 30 days of happiness ratings; multilevel modeling tolerates such missing observations. All models were adjusted for age, sex, satisfaction with life scale, weekends, and public holidays. We conducted all of the analyses in R version 4.3.1 (R Core Team, 2022) and RStudio version 2023.06.0.421 (RStudio Team, 2023) and used the lme4 (Bates et al., 2015) package for multilevel modeling analyses.

To test whether the effect of social distancing on happiness levels varied across the 30 days, a random effect of time was estimated at level 1 (within-person). We tested the main effect model using the daily happiness scores of each individual as the dependent variable and social distancing as the independent variable. Other covariates were controlled at level 2 (between-person). The equation for the main effects model was:

Level 1 (within-person)

$$Happiness_{ij} = \beta_0 + \beta_{1j} * Time_{ij} + e_{ij}$$

Level 2 (between-person)

$$\begin{aligned}\beta_0 = {} & \gamma_0 + \gamma_1 * Neuroticism_j + \gamma_2 * Extraversion_j + \gamma_3 * Openness_j \\ & + \gamma_4 * Agreeableness_j + \gamma_5 * Consciousness_j + \gamma_6 * Social\ distancing_j \\ & + \gamma_7 * Holiday_i + \gamma_8 * Weekend_i + \gamma_9 * Satisfaction\ about\ life_i \\ & + \gamma_{10} * Age_i + \gamma_{11} * Sex_i\end{aligned}$$

Note: β_0 is the intercept of the model; β_{ij} is the regression coefficient for the *j*th group; $Time_{ij}$ is the value of the independent variable "time" for the *i*th observation in the *j*th group; and e_{ij} is the error term, which represents the unobserved factors that contribute to the variation in the dependent variable "happiness" that are not captured by the independent variable "time" or the model's coefficients.

To further examine whether the relationship between social distancing and happiness levels varied over periods as a function of the Big Five personality factors, we tested the interaction effects model with five interaction terms between personality traits and social distancing (one for each Big Five personality factor) and covariates. The equation for the interaction effects model was:

Level 1 (within-person)

$$Happiness_{ij} = \beta_0 + \beta_{1j} * Time_{ij} + e_{ij}$$

Level 2 (between-person)

$$\begin{aligned}\beta_0 = {} & \gamma_0 + \gamma_1 * Neuroticism_j + \gamma_2 * Extraversion_j + \gamma_3 * Openness_j \\ & + \gamma_4 * Agreeableness_j + \gamma_5 * Consciousness_j + \gamma_6 * Social\ distancing_i \\ & + \gamma_7 * Holiday_i + \gamma_8 * Weekend_i + \gamma_9 * Satisfaction\ about\ life_i \\ & + \gamma_{10} * Age_i + \gamma_{11} * Sex_i + \gamma_{12} * Neuroticism_j * Social\ distancing_i \\ & + \gamma_{13} * Extraversion_j * Social\ distancing_i + \gamma_{14} * Openness_j * Social\ distancing_i \\ & + \gamma_{15} * Agreeableness_j * Social\ distancing_i + \gamma_{16} * Consciousness_j * Social\ distancing_i\end{aligned}$$

Note: β_0 is the intercept of the model; β_{ij} is the regression coefficient for the *j*th group; $Time_{ij}$ is the value of the independent variable "time" for the *i*th observation in the *j*th group; and e_{ij} is the error term, which represents the unobserved factors that contribute to the variation in the dependent variable "happiness" that are not captured by the independent variable "time" or the model's coefficients.

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Corrigendum

Corrigendum to "Extraverts suffer from social distancing: A 30-day diary study" [Pers. Individ. Differ. 218 (2024) 112433]

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The authors regret to report that two typos were found in the original text and would like to correct them accordingly. The corrections do not influence the results and conclusions of the original article.

In Section 2.1, "… 611 participants (46% female) were included in the final dataset …" should be corrected to "… 611 participants (54% female) were included in the final dataset …".

In Section 2.4, "Males and females were coded with 0 and 1 …" should be corrected to "Females and males were coded with 0 and 1 …".

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