

AGE, SOCIAL INTERACTIONS, AND WELL-BEING

The Mediating Effect of Loneliness Towards The Relations Between Face-to-face And Virtual Interactions  
And Psychological Well-being Across Age: A 21-day Diary Study

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## Abstract

Lack of social interaction is associated with a heightened sense of loneliness and, in turn, poorer psychological well-being. Despite the prevalence of communicating with others virtually even when physically alone, whether the social interaction–loneliness–well-being relationship is different between face-to-face and virtual interactions and between younger and older adults is relatively understudied. This 21-day diary study examined this question among younger ( $n=91$ ;  $M_{\text{age}}=22.87$ ) and older ( $n=107$ ;  $M_{\text{age}}=64.53$ ) Hong Kong participants during the early stage of the COVID-19 pandemic (March–May 2020). We found significant indirect effects of shorter face-to-face interaction time on poorer psychological well-being via a heightened sense of loneliness at the within-person level only among younger adults and at the between-person level only among older adults. Independent of loneliness, spending more time than others on virtual interactions was associated with better psychological well-being only among older adults. Taken together, while the mechanisms may be different across age groups, face-to-face interaction remains an effective way to reduce loneliness and enhance psychological well-being even at times when it is discouraged (e.g., pandemic). Although virtual interaction does not reduce loneliness, its positive impact on older adults' well-being sheds light on the utility of promoting technological acceptance in late adulthood.

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### Introduction

As social animals, connections with other humans are essential for psychological well-being. For many years in human history, social interactions can happen only when people are in the same physical space. The invention of information and communications technology has radically shifted the landscape of social interaction. As such, whereas solitude was commonly defined as “physical removal from others” in the past (e.g., Coplan & Bowker, 2014), recent theoretical advancement has highlighted the need to reconceptualize the meaning of solitude in the digital era from “being alone” to “no communication with others” (Chui et al., 2014). The boundary between physical aloneness and virtual interaction becomes less clear, as evidenced by studies showing that solitude is associated with more social media communications (Wang et al., 2012), and about 30% of the time alone is, in fact, spent on communicating with others virtually (Thomas et al., 2021). Virtual interaction is getting more popular among people of all ages. According to Hong Kong Census and Statistic Department (2021), 99% of citizens used the Internet for social interaction. Such reliance on digital communication for social connection has become more prevalent along with the social restriction measures during the COVID-19 pandemic (Nguyen et al., 2020). Given the increasing popularity and importance of virtual interaction when people are physically isolated, the current study focused on understanding the impacts of virtual interaction, in comparison with face-to-face interaction, on loneliness and psychological well-being.

### Mixed Effect of Solitude

Findings regarding the effect of time with “no communication” on psychological well-being are mixed. The mainstream findings are that solitude is associated with heightened cortisol levels and more negative affect and less positive affect for college students (Matias et al., 2011). It is also associated with less positive affect and more boredom among older adults (Chui et al., 2014). Nevertheless, recent findings have also revealed some benefits of solitude. Birditt and colleagues (2005) suggested that solitude might be an effective conflict-resolution strategy for older adults under social tensions. Nguyen et al. (2018) found a

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positive effect of solitude on affect regulation when people chose to be alone. Freedom of choice and enhanced creativity were also suggested as the beneficial byproducts of the solitary experience (Long & Averill, 2003). These mixed findings may be accounted for by the inconsistent operational definitions of solitude (physically isolated vs. no communication). The current study focuses on the presence/absence of face-to-face/virtual social interactions and their associations with well-being.

Pauly and colleagues (2017) compared the between-person and within-person effects of solitude on affective experience in the same study, and suggested that whether solitude might be beneficial might depend on the level of analysis. At the between-person level, more time spent alone (i.e., no communication physically or virtually) was related to less high arousal positive affect and more average cortisol level. Yet, at the with-person level, more state solitude reported was related to more low arousal positive affect. These findings suggest the necessity to examine the effect of no communication on psychological well-being at both the between-person and within-person levels. Likewise, we distinguish between between-person and within-person levels in the current study. Moreover, as this study did not distinguish between no communication physically and virtually, we aimed at making this distinction in the current study.

### **Virtual (vs. Face-to-face) Social Interactions and Psychological Well-being across Age**

Similar to the mixed findings cited earlier regarding the effect of solitude, the effect of interaction format (face-to-face vs. virtual) on psychological well-being are also mixed, especially when age is considered. For younger adults, while one study found that experimentally induced interactions on social media reduced loneliness (Deters & Mehl, 2013), most studies showed that face-to-face interactions' contribution to psychological well-being outweighed virtual interactions. For example, Jin and Park (2013) found that having more face-to-face interactions was related to lower levels of loneliness, while having virtual interactions via a mobile phone was related to higher levels of loneliness. In another study, younger adults reported higher levels of loneliness after virtual interactions than after face-to-face interactions (Hu, 2009). Conversely, most studies with older participants have found that virtual interactions enhance psychological well-being, except for a population-based study in which the frequency of face-to-face (but

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not virtual) interactions was associated with reduced risk of having depressive symptoms (Teo et al., 2015). Older adults with more frequent social media communication perceived greater social support and social contact, which contributed to lower levels of loneliness (Zhang et al., 2021). A recent study directly compared the effect of virtual interaction on social connectedness and loneliness between age groups (Wetzel et al., 2021). Whereas virtual interaction was beneficial to older adults indicated by reduced loneliness and a higher sense of connectedness, the opposite was found among younger adults.

One potential explanation for the observed trend is that virtual interactions may serve different functions for younger and older adults. According to socioemotional selectivity theory (SST), people prioritize different goals as their time horizon changes with age (Carstensen, 1995). While younger adults are more motivated to expand their social network, older adults are more motivated to strengthen emotionally meaningful social ties. Erikson (1963)'s theory of psychosocial development also argues that while emerging adults are exploring their identities (Arnett, 2004), older adults seek to integrate what they have already had. Compared to older adults, the content of virtual interactions among younger adults may be more diverse. Rather than engaging in one-on-one virtual interactions like texting a friend or family member for social connection, younger adults also adopt social media as a platform for self-presentation and exploration (e.g., posting photos, expressing thoughts). Although this serves social exploratory functions, the virtual interactions, often with people whom they are unfamiliar with, could be negative (e.g., cyberbullying) and result in harmful psychological outcomes (e.g., Nesi & Prinstein, 2015) such as depression. Conversely, older adults mostly use virtual interactions in maintaining and strengthening existing relationships, but not in developing new relationships (Quan-Haase et al., 2017). For instance, unlike younger adults who reported a relatively larger friend list on a social media platform (i.e., Facebook), older adults reported a relatively smaller and selected list on Facebook, and used Facebook to strengthen existing social relationships. Chang and colleagues (2015) argued that older adults' virtual interactions reflected more of their actual social network, and therefore contributed to reduced loneliness and better psychological well-being to a greater extent than those of younger adults. A qualitative study also reported that older adults considered virtual exchanges real and meaningful (Quan-Haase et al., 2017). As such, older adults may enjoy better

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psychological well-being from having virtual interactions than do younger adults because they engage in virtual interactions more selectively, focusing on familiar social contacts who provide more predictable interactions.

### **The Mediating Role of Loneliness**

The above discussion suggests that a lack of face-to-face and virtual communication may reduce psychological well-being by leaving a person's social needs unfulfilled. This mediating mechanism is known as loneliness in the literature. Loneliness is a negative subjective feeling when one perceives a discrepancy between the desired and received social connection (Peplau & Perlman, 1982). Cohn-Schwartz et al. (2022) found an impact of reduced in-person and electronic social contact on loneliness during the COVID-19 pandemic. More importantly, Park and colleagues (2013) found that the beneficial influence of face-to-face social interactions on depressive symptoms was explained by a reduction of loneliness. Another study (Chopik, 2016), which focused on virtual interactions, also found a similar mediation: the reduction of loneliness significantly mediated the relationship between higher social technology usage and better psychological well-being (e.g., fewer depressive symptoms). A recent study found that more virtual interaction was related to better emotional, psychological, and social well-being through the reduction of loneliness (Sahi et al., 2021). However, none of these studies examined face-to-face and virtual interactions simultaneously. Nor did they compare those effects across age groups. Moreover, these studies captured the cross-sectional, between-person effects only. Within-person changes—the day-to-day variations of interaction time compared to a person's usual social engagement—were not studied. As reviewed above, examining both between-person and within-person effects is important because momentarily limited social interactions (within-person effects) might be less harmful than chronically fewer social interactions relative to others (between-person effects; Pauly et al., 2017).

To address these gaps in the literature, we conducted a 21-day daily diary study with younger and older adults to examine both between- and within-person relationships among social interactions (face-to-face vs. virtual), loneliness, and psychological well-being simultaneously. We hypothesize that loneliness would

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mediate the relationship between social interactions (face-to-face and virtual) and psychological well-being. In particular, face-to-face interaction was expected to be associated positively with psychological well-being via a reduction of loneliness regardless of age, while virtual interaction would be associated positively with psychological well-being among older adults via a reduction of loneliness but negatively among younger adults via an increase of loneliness.

## Methods

### Participants

This 21-day diary study is part of a research project investigating the daily experiences at the early stage of the COVID-19 pandemic [see Chu et al., 2021]. We recruited 91 younger ( $M_{\text{age}}=22.87$ ,  $SD=4.35$ , range=18–34; 61.54% female) and 107 older ( $M_{\text{age}}=64.53$ ,  $SD=4.72$ , range=60–84; 63.55% female) participants; three of them dropped out from the study. While we determined the targeted sample size based on a priori power analysis reported elsewhere [Chu et al., 2021d], post-hoc power analyses indicated that the sample size was sufficient to detect a Level-2 (person-level) indirect effect as small as  $\beta=.09$  with statistical power=.80 and alpha=.05 in a mediation model (Kenny, 2017). It was also sufficient to detect a model fit difference in root mean square error of approximation (RMSEA)=.08 (vs. null RMSEA=.05) with statistical power=.80 and alpha=.05 in structural equation modeling (Preacher & Coffman, 2006). We collected data in Hong Kong from March 9 to May 4, 2020, during which the cumulative COVID-19 cases of the city rose from 115 to 1,040 (out of a 7-million population; Dong et al., 2020). Before the data collection, the city government had advised people to reduce social contacts and advocated for a work-from-home arrangement. The inclusion criteria were (a) proficient in reading and typing Chinese, (b) within the age ranges (18–34 for younger adults and 60+ for older adults), and (c) no known psychological or neurological conditions. Table 1 presents the demographic information of the younger and older subsamples. Older (vs. younger) participants were more likely to receive less education, be married or in a relationship, have acquired at least one chronic health condition, and perform worse in verbal fluency and digit forward tasks.

### Procedure

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The Survey and Behavioral Research Ethics Committee of The Chinese University of Hong Kong (Reference number: SBRE-19-472) approved this study. After obtaining participants' informed consent, we sent the daily survey link to the participants via email or a social media application (WhatsApp) every evening for 21 consecutive days. To increase motivation and to answer questions if any, we gave participants three follow-up phone calls on Days 2, 12, and 19.

### Measures

We measured affective balance, meaning in life, depressive symptoms (collectively, psychological well-being), sense of loneliness, and number of hours spent interacting face-to-face and virtually with different social partners every day (Level-1 variables), and chronic health conditions and other demographics (see below) at the baseline only (Level-2 variables). We also measured cognitive performance by asking participants to perform the cognitive tasks described below over the phone, as part of the three follow-up phone calls over the 21-day data collection period.

**Affective Balance.** Participants reported to what extent they felt excited, enthusiastic, relaxed, calm, sleepy, sluggish, fearful, and nervous in the past 24 hours on a 5-point Likert scale from 0 (*Not at all*) to 4 (*Extremely*). This was a list of affective states abridged from the Affect Valuation Inventory (Tsai et al., 2006) covering the 2 (arousal: high, low)  $\times$  2 (valence: positive, negative) affective circumplex (Russell, 1980). We reverse-coded the negatively-valenced items and computed an average composite score, with greater values indicating more positive affective balance. Because the high and low arousal affective states did not always co-exist, the within- and between-person reliability coefficients were .58 and .98, respectively. The reliability was also similar to those of previous diary and experience sampling studies using affective items that included both high and low arousal levels (e.g., Jiang et al., 2019).<sup>1</sup>

**Meaning in Life.** Adapted from Steger and colleagues (2008), the Daily Meaning Scale asked participants to rate “how meaningful did my life feel” and “how much did I feel my life had purpose” based on their experiences on that day. Participants responded on a 7-point Likert scale from 1 (*Not at all*) to 7



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(*Very much*). Higher average scores indicate greater daily meaning in life. The within- and between-person correlation coefficients between the items were .58 and .99, respectively (both  $ps < .001$ ).

**Depressive Symptoms.** Previous studies (e.g., Bauer et al., 2018) have adapted the two-item Patient Health Questionnaire–2 to measure the severity of daily depressive symptoms (Kroenke et al., 2003). In this study, participants indicated whether they had experienced “little interest or pleasure in doing things” and “feeling down, depressed or hopeless” on a 4-point Likert scale from 0 (*Not at all*) to 3 (*Nearly the whole day*). Higher scores reflect more severe depressive symptoms on that day. The within- and between-person correlation coefficients were .34, and .85, respectively (both  $ps < .001$ ).

**Sense of Loneliness.** Participants reported to what extent they felt “lonely” and “isolated” in the past 24 hours on a 5-point Likert scale from 0 (*Not at all*) to 4 (*Extremely*). Higher average scores indicated stronger senses of loneliness on that day. The within- and between-person correlation coefficients were .45 and .94, respectively (both  $ps < .001$ ).

**Face-to-Face and Virtual Interaction Time.** Participants indicated the total number of hours spent on interacting with (a) family and partner, (b) friends, (c) people in the community, and (d) others face-to-face and virtually on that day.<sup>2</sup>

**Chronic Health Conditions.** Participants reported whether they had been diagnosed with any of the 12 chronic health conditions (e.g., asthma, hypertension). Because many participants reported none of the conditions, we dichotomized this variable to a dummy variable with (0=*no chronic health condition*, 1=*at least one condition*).

**Cognitive Task Performance.** Participants completed the verbal fluency task and forward and backward digit span recall tasks in a counterbalanced order during the three follow-up phone calls (Thaipisuttikul et al., 2014). We selected these tasks because they had been used on both younger and older samples, covering different cognitive functions (e.g., working memory/temporary information storage, verbal memory/semantic knowledge organization), and were easy to administer over the phone. Higher scores indicate better cognitive performances.

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**Other Demographics.** Participants reported their gender (0=*Male*, 1=*Female*), education level (0=*Below postsecondary*, 1=*Postsecondary or above*), monthly household income, relationship status (0=*Others*, 1=*Married/In a relationship*), and living arrangement (0=*Living with others*, 1=*Living alone*).

### Analysis

We performed multi-group multilevel path analyses using the R package “lavaan” to estimate the regression paths among interaction time, sense of loneliness, and psychological well-being among younger and older adults separately (Rosseel, 2012). Compared to single-level path analyses and multilevel modeling, this approach was more favorable because it accounted for the nested structure of the diary data (Level 1: day [ $k=3,894$ ], Level 2: person [ $N=198$ ]; Bolger & Laurenceau, 2013), and it could estimate chained associations (interaction time→sense of loneliness→well-being) and multiple outcome variables (affective balance, depressive symptoms, meaning in life) simultaneously (Preacher et al., 2010). We computed the indirect effects by estimating the products of the paths from the predictors to the mediator, and those from the mediator to the outcomes (Kline, 2015). We employed a maximum likelihood estimation with robust (Huber-White) standard errors (“MLR” estimator) to account for incomplete and non-normal data. We determined a good model fit with comparative fit index (CFI) $>.95$ , RMSEA $<.06$ , and standardized root mean squared residual (SRMR) $<.08$  (Hu & Bentler, 1999).

## Results

### Descriptive Statistics

Table 1 presents the person-level statistics of younger and older participants. Older (vs. younger) adults reported more positive affective balance, greater meaning in life, less severe depressive symptoms, and a lower sense of loneliness. There was no significant difference in face-to-face interaction time between age groups, although older adults spent less time on virtual interactions than did younger adults. Table 2 presents the correlation coefficients. Because education level, relationship status, living arrangement, chronic health conditions, backward digit span recall performance significantly correlated with the target variables, we included these variables as covariates in subsequent analyses. Previous studies have also

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revealed the relations of these variables to age, technology use, interaction time, and well-being (e.g., Lay et al., 2020), suggesting the empirical and conceptual necessity to account for these covariates. Because “lavaan” can only handle missing data by listwise deletion, subsequent analyses excluded participants with missing data in any covariates, resulting in the final  $n_{\text{Younger}}=89$  and  $n_{\text{Older}}=102$ .

### Multi-group Multilevel Path Analysis

We specified the multi-group multilevel path model to estimate the direct and indirect effects of face-to-face/virtual interaction time on affective balance/meaning in life/depressive symptoms via sense of loneliness among younger and older adults separately. The path model demonstrated a good fit, CFI=.991, RMSEA=.035, 90% CI [.009, .061], SRMR<sub>within</sub>=.013, SRMR<sub>between</sub>=.012. Figure 1 and Supplemental Table S1 present the standardized path estimates of the proposed model, whereas Table 3 shows the indirect effect estimates.

**Within-person Level Estimates.** Greater face-to-face interaction time was associated with a lower sense of loneliness for both younger and older adults. For both age groups, a greater sense of loneliness was associated with more negative affective balance, less meaning in life, and more severe depressive symptoms on the same day. For the direct effects of interaction time on psychological well-being independent of loneliness, more face-to-face interaction time was associated with more positive affective balance, greater meaning in life, and less severe depressive symptoms, only among younger but not older adults.

For the hypothesized indirect effects of interaction time on well-being via loneliness, the within-person, indirect effects of face-to-face interaction time were significant only among younger but not older adults. For virtual interaction time, none of the within-person, indirect effects on psychological well-being via loneliness was statistically significant among either age group.

**Between-person Level Estimates.** Greater face-to-face interaction time was associated with a lower sense of loneliness among older but not younger adults. Virtual interaction time was not associated with a sense of loneliness in both age groups. For both age groups, a greater sense of loneliness was related to worse psychological well-being. For the direct effects, independent of loneliness, more face-to-face

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interaction time was associated with more positive affective balance, greater meaning in life, and less severe depressive symptoms among younger adults. Interestingly, although virtual interaction time did not have a significant direct effect on any psychological well-being indicators among younger adults, it was associated with more positive affective balance, greater meaning in life, and less severe depressive symptoms among older adults.

For the hypothesized indirect effects of interaction time on well-being via loneliness, contrary to the within-person counterparts, the between-person, indirect effects of face-to-face interaction time were significant only among older but not younger adults. For virtual interaction time, none of the between-person, indirect effects was statistically significant among either age group.

### Lagged and Alternative Models

A mediation model with variables measured simultaneously falls short in evaluating their temporal sequence. To address this shortcoming, we reran the multi-group multilevel model by replacing the outcomes with next day's psychological well-being indicators. The time-lagged model also demonstrated a good fit, CFI=.998, RMSEA=.015, 90% CI [.000, .044], SRMR<sub>within</sub>=.011, SRMR<sub>between</sub>=.010, and the path estimates were in the same direction compared to the original model, although the regression path from sense of loneliness to next day's meaning in life became non-significant (see Supplemental Figure S1 and Table S2). Additionally, we evaluated alternative models of reverse causality, in which we specified sense of loneliness as the predictor (loneliness→interaction time→well-being) or the outcome (interaction time→well-being→loneliness). Both models showed a poorer fit with the data compared to the original model (see Supplemental Table S3; see also Kuha, 2004 for the non-nested model comparison), providing further support to the original path model.

## Discussion

This 21-day diary study examined the within- and between-person relationships among face-to-face/virtual interaction time, sense of loneliness, and psychological well-being among younger and older adults during the early stage of the COVID-19 pandemic in Hong Kong. The data partially supported our

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hypotheses. As hypothesized, at the between-person level, we found beneficial effects of face-to-face interaction on loneliness reduction and, in turn, better psychological well-being for older adults only. Likewise, the direct effects of virtual interactions on psychological-well being were significant only for older adults. However, within-person analyses revealed a different story. The indirect effect of face-to-face interaction on psychological well-being via loneliness reduction was significant for younger adults only. Contrary to our hypotheses, no direct or indirect effect of virtual interactions on psychological well-being was significant for any age group.

First, at the between-person level, our findings replicate prior work on the positive association between face-to-face social engagement and psychological well-being among older adults (e.g., Glass et al., 2006). Our findings further add that virtual interactions could have similar benefits on psychological well-being, although not necessarily through reducing loneliness. As for why those benefits were found in older but not younger adults, this might be attributable to the differences in the nature of social interactions for the two age groups. According to SST (Carstensen, 1995), older adults prioritize emotionally meaningful (vs. information-seeking) goals more than younger adults. Older adults are also considered to focus more on maintenance and loss prevention (vs. growth promotion) goals when compared with younger adults (Baltes, 1987). Therefore, for older adults, spending more time on face-to-face interaction may mean that they devote more resources to strengthen their existing close social bonds. These social interactions are more satisfying with fewer negative experiences when compared with those of younger adults (Birditt & Fingerman, 2003), which may contribute to a lower level of loneliness and then better psychological well-being for older adults. Additionally, our findings extend the literature by showing that virtual interactions may be associated with psychological well-being to a greater extent for older than younger adults. This appears counterintuitive as younger adults typically engage in more virtual interactions (e.g., social media) than do older adults. Yet, older adults tend to utilize their virtual interaction time more on strengthening their existing relationships in actual social networks than do younger adults (Wetzel et al., 2021). Similar to our arguments concerning face-to-face interactions, we believe that older adults' virtual interactions tend to be more selective and predictable, which are more likely to enhance psychological well-being. Conversely,

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younger adults' virtual interactions are more diverse and likely to involve unfamiliar social partners, posing them greater risk of negative social experiences (e.g., cyberbullying) that may reduce psychological well-being (Nesi & Prinstein, 2015).

Our findings also advance the literature by revealing that at the within-person level, face-to-face interactions may benefit the psychological well-being of younger adults more than that of older adults. This is achieved at least in part by reducing loneliness. According to Erikson (1963), younger adults are in a period to build relationships and intimacy. According to SST, younger adults prioritize information-seeking goals (Baltes, 1987; Carstensen, 1995). On days when younger adults spend longer-than-usual time on face-to-face interactions, they may expand and develop their social networks, either in quantity or quality, leading to a lower level of loneliness and better psychological well-being. For them, horizon expansion and personal growth mean being better than their usual self, not necessarily in comparison with others. Hence, the benefits of face-to-face interaction time occurs at the within-person level for them, not at the between-person level. Virtual interactions, however, do not seem to have the same benefits at the within-person level. This suggests that spending more time on virtual interactions beyond one's usual level may not reduce loneliness or contribute to psychological well-being for either age group. Taken together, older adults' psychological well-being appears to benefit more from long-term, stable relationships than a sudden burst of longer-than-usual social engagement. This is consistent with their socioemotional goals of maintaining emotionally meaningful relationships as depicted by SST. Conversely, occasional face-to-face social engagement appears sufficient to satisfy younger adults' information-seeking goals and (temporarily) reduce loneliness and enhance psychological well-being.

### **Limitations and Future Directions**

We acknowledge several limitations. First, this study focused on the quantity, rather than the quality, of social interactions. Previous studies suggested that the quality of social interactions concerning the conversation content and the interaction partner also played an important role in determining psychological well-being and social connectedness (Sun et al., 2019). Future studies can consider exploring the moderating

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role of interaction quality in the relationships between interaction time, interaction formats, and well-being for younger and older adults. Second, we used the daily diary design rather than the experiencing sampling method (ESM). The latter will capture the *in-situ* variations of social contexts and experiences and thus will enable future replications to evaluate our findings at the momentary level. Third, the small number of items included in the measures might have contributed to the relatively low within-person reliability coefficients (i.e., .34 to .58). Future studies should consider including more items in the measures. Finally, we collected data during the first phase of the COVID-19 pandemic when many social interactions were switched from face-to-face to virtual given the social restriction policies. Future studies should test the findings' generalizability in other social isolation contexts.

## Conclusion

Maintaining virtual interactions has become very common even when people are physically alone. However, our findings suggest that face-to-face (vs. virtual) interaction was still a more effective way to reduce loneliness and enhance psychological well-being, even at times when it was discouraged (e.g., pandemic). This study contributes to the literature by revealing the within- and between-person effects of face-to-face interaction on well-being that are consistent with the theorized socioemotional goal differences between younger and older adults. Virtual interaction, despite its limited effect on loneliness reduction, can contribute to older adults' psychological well-being, highlighting the potential benefits of promoting technological acceptance in late adulthood. Thayer and Ray (2006) has proposed the concept "digital solidarity" to suggest that at least some older adults are likely to use virtual interaction as a means to unite with family and friends, to connect and support one another. Our findings provide further support for this possibility.

## Endnotes

1. Another common approach is to analyze positive and negative affect separately as two composites. We ran the same analyses with these composites instead of affective balance and found results consistent with the findings reported (see Supplementary Materials).

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2. We conducted supplementary analyses to investigate the effects of face-to-face and virtual interaction time on loneliness and psychological well-being, split by interaction time with (a) family and partner and (b) other social targets (friends, people in the community, “others”). Overall, it appears that the indirect effects of interaction time on psychological well-being via loneliness in the original model were mostly driven by the time spent with family and partner (see Supplementary Materials).



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Table 1.

*Descriptive statistics of the younger and older adult subsamples.*

Variables	<i>M(SD)/n(%)</i>		<i>t/χ<sup>2</sup></i>	<i>p</i>	<i>d</i>
	Younger adults ( <i>n</i> = 91)	Older adults ( <i>n</i> = 107)			
Age	22.87 (4.35)	64.53 (4.72)	-64.15	< .001	-9.18
Gender (% woman)	56 (61.5%)	68 (63.6%)	0.02	.885	
Education (% postsecondary or above)	90 (98.9%)	42 (39.3%)	76.08	< .001	
Relationship (% married/in a relationship)	34 (37.4%)	84 (80.0%)	35.23	< .001	
Living arrangement (% living alone)	2 (2.2%)	10 (9.4%)	3.25	.072	
Household income (1–8)	5.06 (1.49)	4.77 (1.94)	1.12	.264	0.17
Chronic health conditions (% 1 or more)	8 (8.8%)	58 (54.2%)	43.62	< .001	
Cognitive task performance					
Verbal fluency	20.45 (4.49)	17.17 (4.73)	4.93	< .001	0.71
Forward digit span recall	6.51 (0.78)	6.14 (1.09)	2.71	.007	0.39
Backward digit span recall	5.52 (1.51)	5.21 (1.51)	1.40	.163	0.21
Daily affective balance (0–4) <sup>a</sup>	2.12 (0.35)	2.52 (0.50)	-6.51	< .001	-0.93
Daily meaning in life (1–7) <sup>b</sup>	4.08 (1.20)	5.02 (1.25)	-5.38	< .001	-0.77
Daily depressive symptoms (0–6) <sup>c</sup>	1.55 (0.43)	1.21 (0.31)	6.26	< .001	0.91
Daily sense of loneliness (0–4) <sup>d</sup>	1.18 (1.31)	0.78 (1.20)	2.20	.029	0.32
Daily face-to-face interactions (hours)	2.77 (2.45)	3.39 (3.43)	-1.47	.143	-0.21
Daily virtual interactions (hours)	1.36 (1.08)	0.76 (0.94)	4.12	< .001	0.59

*Note.* For household income, 1 = less than HKD3,000, 2 = HKD3,001–8,500, 3 = HKD8,501–14,000, 4 = 14,001–20,000, 5 = HKD20,001–29,999, 6 = HKD30,000–59,999, 7 = HKD60,000–99,999, and 8 = HKD100,000 or more. <sup>a</sup>Scale ranged from 0 (Not at all) to 4 (Extremely). <sup>b</sup>Scale ranged from 1 (Not at all) to 7 (Very much). <sup>c</sup>Scale ranged from 0 (Not at all) to 3 (Nearly the whole day). <sup>d</sup>Scale ranged from 0 (Not at all) to 4 (Extremely).



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performance

Older adults

1. Depressive symptoms <sup>a</sup>	—	<b><u>-.561</u></b>	<b><u>-.404</u></b>	<b><u>.776</u></b>	-.095	<b><u>-.182</u></b>	-.003	.093	-.043	-.074	.019	-.205	.043	.105	-.210
2. Affective balance <sup>b</sup>	<b><u>-.276</u></b>	—	<b><u>.567</u></b>	<b><u>-.584</u></b>	-.037	.286	-.004	.090	-.130	<b><u>.265</u></b>	.037	-.035	.072	.004	<b><u>.228</u></b>
3. Meaning in life <sup>c</sup>	<b><u>-.133</u></b>	.062	—	<b><u>-.340</u></b>	.080	<b><u>.233</u></b>	.165	.112	.062	.160	-.155	-.011	.043	.052	.121
4. Sense of Loneliness <sup>d</sup>	<b><u>.247</u></b>	<b><u>-.263</u></b>	-.068	—	<b><u>-.162</u></b>	-.082	.127	.027	-.042	-.072	-.119	-.154	.044	.020	<b><u>-.295</u></b>
5. Face-to-face interaction time	-.058	.049	-.027	-.048	—	-.012	-.101	<b><u>-.248</u></b>	.177	<b><u>-.284</u></b>	.131	.060	-.038	-.010	-.122
6. Virtual interaction time	-.024	.013	.076	.017	.052	—	-.126	.035	.087	-.038	<b><u>.193</u></b>	-.039	-.110	-.027	.048
7. Gender						—		<b><u>-.219</u></b>	<b><u>-.382</u></b>	<b><u>.261</u></b>	<b><u>-.321</u></b>	<b><u>-.301</u></b>	<b><u>-.283</u></b>	-.085	-.127
8. Education								—	<b><u>.199</u></b>	-.073	.173	<b><u>.245</u></b>	<b><u>.295</u></b>	.157	.113
9. Relationship									—	<b><u>-.685</u></b>	.125	<b><u>.382</u></b>	.064	-.033	-.031
10. Live alone										—	-.101	-.274	.046	.068	.148
11. Health conditions											—	-.002	.159	-.086	.019
12. Household income												—	.175	.008	<b><u>.253</u></b>
13. Verbal fluency													—	.118	<b><u>.182</u></b>
14. Forward digit span recall performance														—	<b><u>.332</u></b>
15. Backward digit span recall performance															—

Note.  $n_{\text{Younger}} = 89$ ,  $k_{\text{Younger}} = 1,832$ ;  $n_{\text{Older}} = 102$ ,  $k_{\text{Older}} = 2,062$ . <sup>a</sup>Scale ranged from 0 (Not at all) to 3 (Nearly the whole day). <sup>b</sup>Scale ranged from 0 (Not at all) to 4 (Extremely). <sup>c</sup>Scale ranged from 1 (Not at all) to 7 (Very much). <sup>d</sup>Scale ranged from 0 (Not at all) to 4 (Extremely). For gender, 0 = man, 1 = woman. For education, 0 = secondary or below,

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1 = postsecondary or above. For relationship, 0 = other relationship statuses, 1 = married or in a relationship. For health conditions, 0 = no chronic health conditions, 1 = one or more chronic health conditions. For the correlational matrices, whereas within-person correlation coefficients are below the diagonals, between-person correlation coefficients are above the diagonals. Statistically significant ( $p < .05$ ) correlation coefficients are bolded and underlined.



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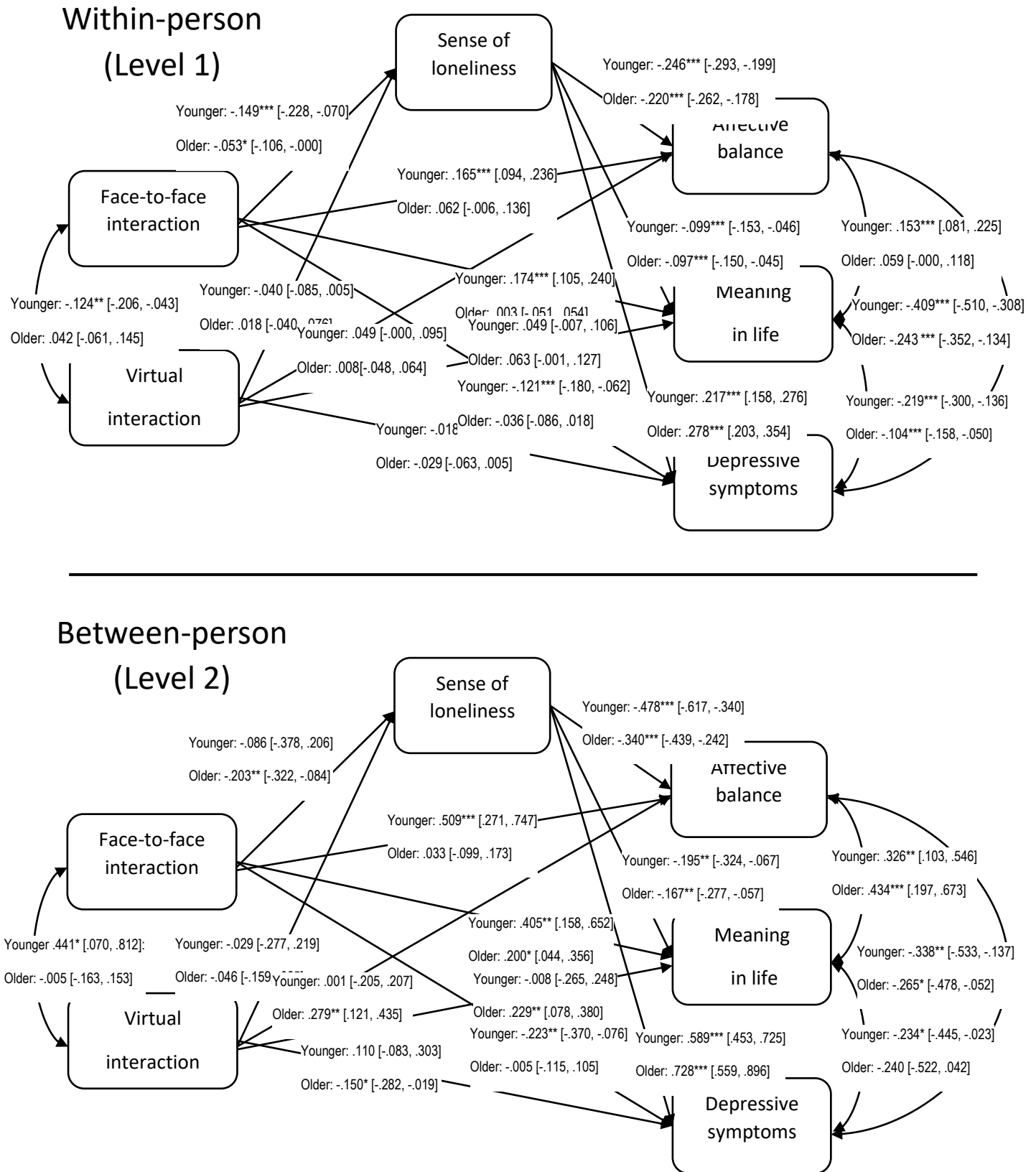


Figure 1.  $n_{\text{Younger}} = 89$ ,  $k_{\text{Younger}} = 1,832$ ;  $n_{\text{Older}} = 102$ ,  $k_{\text{Older}} = 2,062$ . Multigroup multilevel path model with face-to-face/virtual interaction time, sense of loneliness, affective balance, meaning in life, and depressive symptoms among younger and older adults, split into within- (top: Level-1) and between-person (bottom; Level-2) components. All estimates were standardized within their corresponding 95% confidence levels (in brackets). Whereas single-arrow lines represent regression paths, double-arrow lines represent correlations. See Supplemental Table S1 for the full list

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of estimates, including covariates, namely Education level, relationship status, living arrangement, chronic health conditions, and backward digit span recall task performance, omitted in this figure for parsimony.

\*  $p < .05$ . \*\*  $p < .01$ . \*\*\*  $p < .001$ .

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**Table 3.***Standardized Estimates, p-values, and 95% Confidence Intervals of Within- and Between-person Indirect Effects among Younger and Older Adults*

Estimates	Younger adults			Older adults		
	$\beta$	$p$	95% CI	$\beta$	$p$	95% CI
Level-1 (Within-person)						
Face-to-face interaction time → Sense of loneliness → Affective balance	<b>.037</b>	< <b>.001</b>	<b> [.019, .062]</b>	.012	.056	[-.000, .024]
Face-to-face interaction time → Sense of loneliness → Meaning in life	<b>.015</b>	<b>.014</b>	<b> [.004, .030]</b>	.005	.077	[-.000, .015]
Face-to-face interaction time → Sense of loneliness → Depressive symptoms	<b>-.032</b>	<b>.002</b>	<b> [-.049, -.012]</b>	-.015	.062	[-.030, .000]
Virtual interaction time → Sense of loneliness → Affective balance	.010	.082	[-.000, .023]	-.004	.542	[-.016, .008]
Virtual interaction time → Sense of loneliness → Meaning in life	.004	.126	[-.002, .010]	-.002	.550	[-.012, .006]
Virtual interaction time → Sense of loneliness → Depressive symptoms	-.009	.085	[-.018, .001]	.005	.545	[-.011, .021]
Level-2 (Between-person)						
Face-to-face interaction time → Sense of loneliness → Affective balance	.041	.568	[-.103, .185]	<b>.069</b>	<b>.003</b>	<b> [.023, .115]</b>
Face-to-face interaction time → Sense of loneliness → Meaning in life	.017	.577	[-.043, .079]	<b>.034</b>	<b>.019</b>	<b> [.006, .062]</b>

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Face-to-face interaction time → Sense of loneliness → Depressive symptoms	-.051	.569	[-.224, .125]	<b>-.147</b>	<b>.002</b>	<b>[-.234, -.054]</b>
Virtual interaction time → Sense of loneliness → Affective balance	.014	.819	[-.104, .129]	.016	.420	[-.022, .054]
Virtual interaction time → Sense of loneliness → Meaning in life	.006	.821	[-.049, .061]	.008	.420	[-.012, .029]
Virtual interaction time → Sense of loneliness → Depressive symptoms	-.017	.821	[-.163, .130]	-.034	.423	[-.117, .049]

*Note.*  $n_{\text{Younger}} = 89$ ,  $k_{\text{Younger}} = 1,832$ ;  $n_{\text{Older}} = 102$ ,  $k_{\text{Older}} = 2,062$ . All estimates were standardized within the level. Statistically significant indirect effect estimates ( $p < .05$ ) are bolded. Education level, relationship status, living arrangement, chronic health conditions, and backward digit span recall task performance were covariates. See Supplemental Table S1 for the full list of estimates including covariates.

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## Supplemental Table S1.

*Standardized Estimates, p-values, and 95% Confidence Intervals of Within- and Between-person Indirect Effects among Younger and Older Adults*

Estimates	Younger adults			Older adults		
	$\beta$	$p$	95% CI	$\beta$	$p$	95% CI
Level-1 (Within-person)						
Regressions						
Face-to-face interaction time → Sense of loneliness	<b>-.149</b>	<b>&lt; .001</b>	<b>[-.228, -.070]</b>	<b>-.053</b>	<b>.045</b>	<b>[-.106, -.000]</b>
Virtual interaction time → Sense of loneliness	-.040	.075	[-.085, .005]	.018	.542	[-.040, .076]
Sense of loneliness → Affective balance	<b>-.246</b>	<b>&lt; .001</b>	<b>[-.293, -.199]</b>	<b>-.220</b>	<b>&lt; .001</b>	<b>[-.262, -.178]</b>
Face-to-face interaction time → Affective balance	<b>.165</b>	<b>&lt; .001</b>	<b> [.094, .236]</b>	.062	.073	[-.006, .136]
Virtual interaction time → Affective balance	.049	.051	[-.000, .095]	.008	.785	[-.048, .064]
Sense of loneliness → Meaning in life	<b>-.099</b>	<b>&lt; .001</b>	<b>[-.153, -.046]</b>	<b>-.097</b>	<b>&lt; .001</b>	<b>[-.150, -.045]</b>
Face-to-face interaction time → Meaning in life	<b>.174</b>	<b>&lt; .001</b>	<b> [.105, .240]</b>	.003	.930	[-.051, .054]
Virtual interaction time → Meaning in life	.049	.087	[-.007, .106]	.063	.057	[-.001, .127]
Sense of loneliness → Depressive symptoms	<b>.217</b>	<b>&lt; .001</b>	<b> [.158, .276]</b>	<b>.278</b>	<b>&lt; .001</b>	<b> [.203, .354]</b>
Face-to-face interaction time → Depressive symptoms	<b>-.121</b>	<b>&lt; .001</b>	<b>[-.180, -.062]</b>	-.036	.182	[-.086, .018]
Virtual interaction time → Depressive symptoms	-.018	.501	[-.069, .035]	-.029	.092	[-.063, .005]
Correlations						
Face-to-face interaction time ↔ Virtual	<b>-.124</b>	<b>.003</b>	<b>[-.206, -.043]</b>	.042	.425	[-.061, .145]

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interaction time						
Affective balance $\longleftrightarrow$ Meaning in life	<b>.153</b>	<b>&lt; .001</b>	<b> [.081, .225]</b>	.059	.061	[-.000, .118]
Affective balance $\longleftrightarrow$ Depressive symptoms	<b>-.409</b>	<b>&lt; .001</b>	<b>[-.510, -.308]</b>	<b>-.243</b>	<b>&lt; .001</b>	<b>[-.352, -.134]</b>
Meaning in life $\longleftrightarrow$ Depressive symptoms	<b>-.219</b>	<b>&lt; .001</b>	<b>[-.300, -.136]</b>	<b>-.104</b>	<b>&lt; .001</b>	<b>[-.158, -.050]</b>
Indirect effects						
Face-to-face interaction time $\rightarrow$ Sense of loneliness $\rightarrow$ Affective balance	<b>.037</b>	<b>&lt; .001</b>	<b> [.019, .062]</b>	.012	.056	[-.000, .024]
Face-to-face interaction time $\rightarrow$ Sense of loneliness $\rightarrow$ Meaning in life	<b>.015</b>	<b>.014</b>	<b> [.004, .030]</b>	.005	.077	[-.000, .015]
Face-to-face interaction time $\rightarrow$ Sense of loneliness $\rightarrow$ Depressive symptoms	<b>-.032</b>	<b>.002</b>	<b>[-.049, -.012]</b>	-.015	.062	[-.030, .000]
Virtual interaction time $\rightarrow$ Sense of loneliness $\rightarrow$ Affective balance	.010	.082	[-.000, .023]	-.004	.542	[-.016, .008]
Virtual interaction time $\rightarrow$ Sense of loneliness $\rightarrow$ Meaning in life	.004	.126	[-.002, .010]	-.002	.550	[-.012, .006]
Virtual interaction time $\rightarrow$ Sense of loneliness $\rightarrow$ Depressive symptoms	-.009	.085	[-.018, .001]	.005	.545	[-.011, .021]
Level-2 (Between-person)						
Regressions						
Face-to-face interaction time $\rightarrow$ Sense of loneliness	-.086	.568	[-.378, .206]	<b>-.203</b>	<b>.001</b>	<b>[-.322, -.084]</b>
Virtual interaction time $\rightarrow$ Sense of loneliness	-.029	.820	[-.277, .219]	-.046	.415	[-.159, .065]
Relationship $\rightarrow$ Sense of loneliness	-.001	.993	[-.284, .282]	-.089	.572	[-.397, .220]
Health conditions $\rightarrow$ Sense of loneliness	-.043	.635	[-.221, .135]	.016	.874	[-.183, .215]

## AGE, SOCIAL INTERACTIONS, AND WELL-BEING

Education → Sense of loneliness	.029	.663	[-.102, .160]	.077	.459	[-.127, .281]
Live alone → Sense of loneliness	<b>-.102</b>	<b>.003</b>	<b>[-.169, -.035]</b>	-.157	.220	[-.408, .094]
Backward digit → Sense of loneliness	-.003	.977	[-.255, .249]	<b>-.229</b>	<b>.022</b>	<b>[-.427, -.033]</b>
Sense of loneliness → Affective balance	-.478	<b>&lt; .001</b>	[-.617, -.340]	<b>-.340</b>	<b>.000</b>	<b>[-.439, -.242]</b>
Face-to-face interaction time → Affective balance	.509	<b>&lt; .001</b>	[.271, .747]	.033	.601	[-.099, .173]
Virtual interaction time → Affective balance	.001	.991	[-.205, .207]	<b>.279</b>	<b>.001</b>	<b>[.121, .435]</b>
Relationship → Affective balance	-.478	<b>&lt; .001</b>	[-.617, -.340]	-.017	.892	[-.264, .230]
Health conditions → Affective balance	.018	.829	[-.143, .179]	-.003	.976	[-.172, .167]
Education → Affective balance	-.053	.544	[-.223, .118]	.082	.423	[-.118, .282]
Live alone → Affective balance	<b>.137</b>	<b>.010</b>	<b>[.033, .241]</b>	.257	.049	[.002, .513]
Backward digit span recall performance → Affective balance	-.042	.123	[-.095, .011]	.083	.329	[-.083, .249]
Sense of loneliness → Meaning in life	<b>-.195</b>	<b>.003</b>	<b>[-.324, -.067]</b>	<b>-.167</b>	<b>.003</b>	<b>[-.277, -.057]</b>
Face-to-face interaction time → Meaning in life	<b>.405</b>	<b>.001</b>	<b>[.158, .652]</b>	<b>.200</b>	<b>.012</b>	<b>[.044, .356]</b>
Virtual interaction time → Meaning in life	-.008	.948	[-.265, .248]	<b>.229</b>	<b>.003</b>	<b>[.078, .380]</b>
Relationship → Meaning in life	.079	.512	[-.158, .316]	.216	.112	[-.051, .483]
Health conditions → Meaning in life	-.029	.784	[-.237, .179]	<b>-.204</b>	<b>.032</b>	<b>[-.391, -.017]</b>
Education → Meaning in life	.022	.697	[-.089, .133]	.105	.287	[-.088, .298]
Live alone → Meaning in life	-.005	.852	[-.057, .047]	.327	.010	[.078, .576]
Backward digit → Meaning in life	-.071	.470	[-.263, .121]	.122	.186	[-.059, .304]
Sense of loneliness → Depressive symptoms	<b>.589</b>	<b>&lt; .001</b>	<b>[.453, .725]</b>	.728	<b>&lt; .001</b>	[.559, .896]

## AGE, SOCIAL INTERACTIONS, AND WELL-BEING

Face-to-face interaction time → Depressive symptoms	<b>-.223</b>	<b>.003</b>	<b>[-.370, -.076]</b>	-.005	.934	[-.115, .105]
Virtual interaction time → Depressive symptoms	.110	.262	[-.083, .303]	<b>-.150</b>	<b>.025</b>	<b>[-.282, -.019]</b>
Relationship → Depressive symptoms	-.057	.466	[-.211, .096]	-.049	.445	[-.175, .077]
Health conditions → Depressive symptoms	-.044	.437	[-.155, .067]	.082	.225	[-.050, .214]
Education → Depressive symptoms	-.058	.098	[-.127, .011]	.068	.334	[-.070, .205]
Live alone → Depressive symptoms	<b>-.070</b>	<b>.004</b>	<b>[-.118, -.022]</b>	-.046	.480	[-.174, .082]
Backward digit span recall performance → Depressive symptoms	.008	.920	[-.142, .158]	-.052	.483	[-.199, .095]
Correlations						
Face-to-face interaction time ↔ Virtual interaction time	<b>.441</b>	<b>.020</b>	<b> [.070, .812]</b>	-.005	.951	[-.163, .153]
Affective balance ↔ Meaning in life	<b>.326</b>	<b>.004</b>	<b> [.103, .546]</b>	<b>.434</b>	<b>&lt; .001</b>	<b> [.197, .673]</b>
Affective balance ↔ Depressive symptoms	<b>-.338</b>	<b>.001</b>	<b> [-.533, -.137]</b>	<b>-.265</b>	<b>.015</b>	<b> [-.478, -.052]</b>
Meaning in life ↔ Depressive symptoms	<b>-.234</b>	<b>.030</b>	<b> [-.445, -.023]</b>	-.240	.093	[-.522, .042]
Face-to-face interaction time ↔ Relationship	<b>.299</b>	<b>.006</b>	<b> [.087, .511]</b>	.186	.067	[-.013, .386]
Face-to-face interaction time ↔ Health conditions	-.044	.594	[-.204, .116]	.089	.363	[-.103, .281]
Face-to-face interaction time ↔ Education	-.379	.312	[-1.110, .352]	<b>-.229</b>	<b>.007</b>	<b> [-.395, -.064]</b>
Face-to-face interaction time ↔ Live alone	-.120	.314	[-.356, .116]	<b>-.267</b>	<b>.001</b>	<b> [-.423, -.111]</b>
Face-to-face interaction time ↔ Backward digit	.098	.391	[-.126, .322]	-.074	.525	[-.302, .154]
Virtual interaction time ↔ Relationship	<b>.338</b>	<b>.002</b>	<b> [.120, .556]</b>	.089	.185	[-.043, .221]
Virtual interaction time ↔ Health conditions	-.010	.930	[-.230, .210]	<b>.197</b>	<b>.037</b>	<b> [.011, .383]</b>



## AGE, SOCIAL INTERACTIONS, AND WELL-BEING

Virtual interaction time $\leftrightarrow$ Education	.047	.326	[-.047, .150]	.068	.459	[-.114, .250]
Virtual interaction time $\leftrightarrow$ Live alone	.108	.314	[-.108, .324]	-.028	.651	[-.147, .091]
Virtual interaction time $\leftrightarrow$ Backward digit span recall performance	.035	.737	[-.169, .239]	.048	.579	[-.122, .218]
Relationship $\leftrightarrow$ Health conditions	<b>.238</b>	<b>.048</b>	<b> [.000, .476]</b>	.128	.196	[-.067, .328]
Relationship $\leftrightarrow$ Education	.084	.316	[-.084, .273]	<b>.203</b>	<b>.024</b>	<b> [.025, .376]</b>
Relationship $\leftrightarrow$ Live alone	-.084	.316	[-.273, .084]	<b>-.668</b>	<b>&lt; .001</b>	<b> [-1.015, -.313]</b>
Relationship $\leftrightarrow$ Backward digit span recall performance	-.024	.820	[-.228, .180]	-.050	.601	[-.238, .138]
Health conditions $\leftrightarrow$ Education	.034	.338	[-.034, .102]	.172	.075	[-.016, .360]
Health conditions $\leftrightarrow$ Live alone	-.033	.338	[-.099, .033]	-.085	.391	[-.275, .105]
Health conditions $\leftrightarrow$ Backward digit span recall performance	.049	.582	[-.126, .224]	-.008	.938	[-.201, .185]
Education $\leftrightarrow$ Live alone	.011	.477	[-.020, .043]	-.069	.468	[-.255, .117]
Education $\leftrightarrow$ Backward digit span recall performance	-.105	.314	[-.303, .099]	.105	.276	[-.083, .293]
Live alone $\leftrightarrow$ Backward digit span recall performance	-.108	.314	[-.318, .102]	.132	.126	[-.038, .302]
Indirect effects						
Face-to-face $\rightarrow$ Sense of loneliness $\rightarrow$ Affective balance	.041	.568	[-.103, .185]	<b>.069</b>	<b>.003</b>	<b> [.023, .115]</b>
Face-to-face $\rightarrow$ Sense of loneliness $\rightarrow$ Meaning in	.017	.577	[-.043, .079]	<b>.034</b>	<b>.019</b>	<b> [.006, .062]</b>

## AGE, SOCIAL INTERACTIONS, AND WELL-BEING

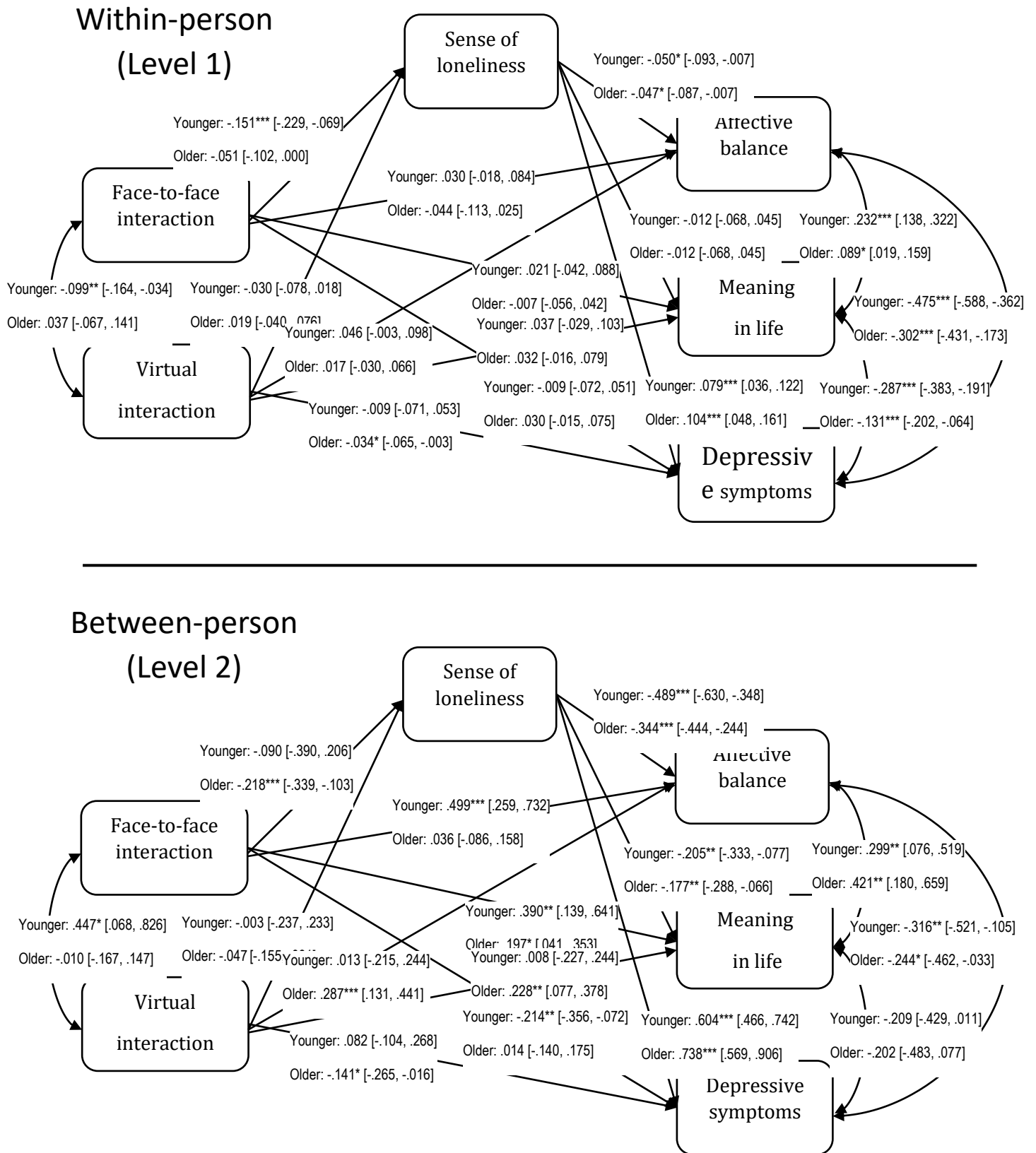
life

Face-to-face → Sense of loneliness → Depressive symptoms	-.051	.569	[-.224, .125]	<b>-.147</b>	<b>.002</b>	<b>[-.234, -.054]</b>
Virtual interaction time → Sense of loneliness → Affective balance	.014	.819	[-.104, .129]	.016	.420	[-.022, .054]
Virtual interaction time → Sense of loneliness → Meaning in life	.006	.821	[-.049, .061]	.008	.420	[-.012, .029]
Virtual interaction time → Sense of loneliness → Depressive symptoms	-.017	.821	[-.163, .130]	-.034	.423	[-.117, .049]

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*Note.*  $n_{\text{Younger}} = 89$ ,  $k_{\text{Younger}} = 1,832$ ;  $n_{\text{Older}} = 102$ ,  $k_{\text{Older}} = 2,062$ . All estimates were standardized within the level. Statistically significant estimates ( $p < .05$ ) are bolded.

AGE, SOCIAL INTERACTIONS, AND WELL-BEING



Supplemental Figure S1.  $n_{\text{Younger}} = 89$ ,  $k_{\text{Younger}} = 1,832$ ;  $n_{\text{Older}} = 102$ ,  $k_{\text{Older}} = 2,062$ . Multigroup multilevel path model with face-to-face/virtual interaction time and sense of loneliness, as well as next day's affective balance, meaning in life, and depressive symptoms among younger and older adults, split into within- (top: Level-1) and between-person (bottom; Level-2) components. All estimates were standardized within their corresponding 95% confidence levels (in

## AGE, SOCIAL INTERACTIONS, AND WELL-BEING

brackets). Whereas single-arrow lines represent regression paths, double-arrow lines represent correlations. See Supplemental Table S2 for the full list of estimates, including covariates, namely Education level, relationship status, living arrangement, chronic health conditions, and backward digit span recall task performance, omitted in this figure for parsimony.

\*  $p < .05$ . \*\*  $p < .01$ . \*\*\*  $p < .001$ .

## AGE, SOCIAL INTERACTIONS, AND WELL-BEING

## Supplemental Table S2.

*Standardized Estimates, p-values, and 95% Confidence Intervals of Within- and Between-person Indirect Effects among Younger and Older Adults Obtained from the Time-lagged Model.*

Estimates	Younger adults			Older adults		
	$\beta$	$p$	95% CI	$\beta$	$p$	95% CI
Level-1 (Within-person)						
Regressions						
Face-to-face interaction time → Sense of loneliness	<b>-.151</b>	<b>&lt; .001</b>	<b>[-.229, -.069]</b>	-.051	.055	[-.102, .000]
Virtual interaction time → Sense of loneliness	-.030	.218	[-.078, .018]	.019	.537	[-.040, .076]
Sense of loneliness → Affective balance <sub>(next day)</sub>	<b>-.050</b>	<b>.022</b>	<b>[-.093, -.007]</b>	<b>-.047</b>	<b>.022</b>	<b>[-.087, -.007]</b>
Face-to-face interaction time → Affective balance <sub>(next day)</sub>	.030	.229	[-.018, .084]	-.044	.203	[-.113, .025]
Virtual interaction time → Affective balance <sub>(next day)</sub>	.046	.065	[-.003, .098]	.017	.477	[-.030, .066]
Sense of loneliness → Meaning in life <sub>(next day)</sub>	-.012	.685	[-.068, .045]	-.012	.685	[-.068, .045]
Face-to-face interaction time → Meaning in life <sub>(next day)</sub>	.021	.492	[-.042, .088]	-.007	.809	[-.056, .042]
Virtual interaction time → Meaning in	.037	.273	[-.029, .103]	.032	.186	[-.016, .079]

## AGE, SOCIAL INTERACTIONS, AND WELL-BEING

life <sub>(next day)</sub>						
Sense of loneliness → Depressive symptoms <sub>(next day)</sub>	<b>.079</b>	<b>&lt; .001</b>	<b>[.036, .122]</b>	<b>.104</b>	<b>&lt; .001</b>	<b>[.048, .161]</b>
Face-to-face interaction time → Depressive symptoms <sub>(next day)</sub>	-.009	.740	[-.072, .051]	.030	.191	[-.015, .075]
Virtual interaction time → Depressive symptoms <sub>(next day)</sub>	-.009	.773	[-.071, .053]	<b>-.034</b>	<b>.036</b>	<b>[-.065, -.003]</b>
Correlations						
Face-to-face interaction time ↔ Virtual interaction time	<b>-.099</b>	<b>.003</b>	<b>[-.164, -.034]</b>	.037	.486	[-.067, .141]
Affective balance <sub>(next day)</sub> ↔ Meaning in life <sub>(next day)</sub>	<b>.232</b>	<b>&lt; .001</b>	<b>[.138, .322]</b>	<b>.089</b>	<b>.011</b>	<b>[.019, .159]</b>
Affective balance <sub>(next day)</sub> ↔ Depressive symptoms <sub>(next day)</sub>	<b>-.475</b>	<b>&lt; .001</b>	<b>[-.588, -.362]</b>	<b>-.302</b>	<b>&lt; .001</b>	<b>[-.431, -.173]</b>
Meaning in life <sub>(next day)</sub> ↔ Depressive symptoms <sub>(next day)</sub>	<b>-.287</b>	<b>&lt; .001</b>	<b>[-.383, -.191]</b>	<b>-.131</b>	<b>&lt; .001</b>	<b>[-.202, -.064]</b>
Indirect effects						
Face-to-face interaction time → Sense of loneliness → Affective balance <sub>(next day)</sub>	.008	.063	[-.000, .024]	.002	.138	[-.001, .006]
Face-to-face interaction time → Sense of loneliness → Meaning in life <sub>(next day)</sub>	.002	.687	[-.004, .006]	.001	.695	[-.002, .004]
Face-to-face interaction time → Sense of loneliness → Depressive symptoms <sub>(next day)</sub>	<b>-.012</b>	<b>.018</b>	<b>[-.022, -.002]</b>	-.005	.108	[-.015, .000]
Virtual interaction time → Sense of	.002	.266	[-.000, .002]	-.001	.557	[-.004, .002]

## AGE, SOCIAL INTERACTIONS, AND WELL-BEING

loneliness → Affective balance<sub>(next day)</sub>

Virtual interaction time → Sense of loneliness → Meaning in life <sub>(next day)</sub>	.000	.693	[-.001, .002]	.000	.702	[-.001, .001]
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Virtual interaction time → Sense of loneliness → Depressive symptoms <sub>(next day)</sub>	-.002	.243	[-.005, .001]	.002	.535	[-.003, .006]
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## Level-2 (Between-person)

## Regressions

Face-to-face interaction time → Sense of loneliness	-.090	.552	[-.390, .206]	<b>-.218</b>	<b>&lt; .001</b>	<b>[-.339, -.103]</b>
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Virtual interaction time → Sense of loneliness	-.003	.981	[-.237, .233]	-.047	.398	[-.155, .061]
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Relationship → Sense of loneliness	-.012	.913	[-.223, .200]	-.072	.624	[-.360, .216]
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Health conditions → Sense of loneliness	-.042	.634	[-.214, .130]	.016	.874	[-.179, .211]
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Education → Sense of loneliness	.027	.684	[-.103, .157]	.072	.488	[-.131, .276]
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Live alone → Sense of loneliness	<b>-.107</b>	<b>.002</b>	<b>[-.174, -.040]</b>	-.149	.227	[-.391, .093]
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Backward digit span recall performance → Sense of loneliness	-.004	.965	[-.170, .164]	<b>-.222</b>	<b>.022</b>	<b>[-.413, -.031]</b>
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Sense of loneliness → Affective balance <sub>(next day)</sub>	<b>-.489</b>	<b>&lt; .001</b>	<b>[-.630, -.348]</b>	<b>-.344</b>	<b>&lt; .001</b>	<b>[-.444, -.244]</b>
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Face-to-face interaction time → Affective balance <sub>(next day)</sub>	<b>.499</b>	<b>&lt; .001</b>	<b>[.259, .732]</b>	.036	.567	[-.086, .158]
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Virtual interaction time → Affective balance <sub>(next day)</sub>	.013	.902	[-.215, .244]	<b>.287</b>	<b>&lt; .001</b>	<b>[.131, .441]</b>
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## AGE, SOCIAL INTERACTIONS, AND WELL-BEING

Relationship → Affective balance <sub>(next day)</sub>	.016	.849	[-.153, .187]	-.030	.811	[-.273, .213]
Health conditions → Affective balance <sub>(next day)</sub>	-.053	.555	[-.228, .123]	-.019	.838	[-.200, .162]
Education → Affective balance <sub>(next day)</sub>	<b>.124</b>	<b>.015</b>	<b> [.024, .224]</b>	.078	.445	[-.122, .278]
Live alone → Affective balance <sub>(next day)</sub>	-.046	.094	[-.100, .008]	.268	.033	[.022, .515]
Backward digit span recall performance → Affective balance <sub>(next day)</sub>	<b>-.155</b>	<b>.034</b>	<b> [-.294, -.012]</b>	.072	.393	[-.091, .235]
Sense of loneliness → Meaning in life <sub>(next day)</sub>	<b>-.205</b>	<b>.002</b>	<b> [-.333, -.077]</b>	<b>-.177</b>	<b>.002</b>	<b> [-.288, -.066]</b>
Face-to-face interaction time → Meaning in life <sub>(next day)</sub>	<b>.390</b>	<b>.002</b>	<b> [.139, .641]</b>	<b>.197</b>	<b>.013</b>	<b> [.041, .353]</b>
Virtual interaction time → Meaning in life <sub>(next day)</sub>	.008	.945	[-.227, .244]	<b>.228</b>	<b>.003</b>	<b> [.077, .378]</b>
Relationship → Meaning in life <sub>(next day)</sub>	.060	.611	[-.171, .291]	.217	.109	[-.048, .482]
Health conditions → Meaning in life <sub>(next day)</sub>	-.048	.657	[-.260, .164]	-.203	.033	[-.390, -.016]
Education → Meaning in life <sub>(next day)</sub>	.014	.796	[-.092, .120]	.106	.284	[-.088, .300]
Live alone → Meaning in life <sub>(next day)</sub>	-.016	.585	[-.074, .042]	<b>.328</b>	<b>.009</b>	<b> [.084, .573]</b>
Backward digit span recall performance → Meaning in life <sub>(next day)</sub>	-.069	.482	[-.259, .122]	.125	.177	[-.057, .307]
Sense of loneliness → Depressive symptoms <sub>(next day)</sub>	<b>.604</b>	<b>&lt; .001</b>	<b> [.466, .742]</b>	<b>.738</b>	<b>&lt; .001</b>	<b> [.569, .906]</b>
Face-to-face interaction time → Depressive symptoms <sub>(next day)</sub>	<b>-.214</b>	<b>.003</b>	<b> [-.356, -.072]</b>	.014	.826	[-.140, .175]
Virtual interaction time → Depressive symptoms <sub>(next day)</sub>	.082	.386	[-.104, .268]	<b>-.141</b>	<b>.027</b>	<b> [-.265, -.016]</b>



## AGE, SOCIAL INTERACTIONS, AND WELL-BEING

symptoms<sub>(next day)</sub>

Relationship → Depressive symptoms <sub>(next day)</sub>	<b>-.045</b>	.555	[-.194, .104]	-.067	.247	[-.180, .047]
Health conditions → Depressive symptoms <sub>(next day)</sub>	-.036	.512	[-.144, .072]	.101	.134	[-.032, .234]
Education → Depressive symptoms <sub>(next day)</sub>	-.053	.112	[-.118, .012]	.063	.374	[-.076, .201]
Live alone → Depressive symptoms <sub>(next day)</sub>	<b>-.058</b>	<b>.016</b>	<b>[-.105, -.011]</b>	-.085	.099	[-.186, .016]
Backward digit span recall performance → Depressive symptoms <sub>(next day)</sub>	.006	.944	[-.184, .198]	-.050	.505	[-.200, .098]

## Correlations

Face-to-face interaction time ↔ Virtual interaction time	<b>.447</b>	<b>.021</b>	<b>[.068, .826]</b>	-.010	.902	[-.167, .147]
Affective balance <sub>(next day)</sub> ↔ Meaning in life <sub>(next day)</sub>	<b>.299</b>	<b>.009</b>	<b>[.076, .519]</b>	<b>.421</b>	<b>.001</b>	<b>[.180, .659]</b>
Affective balance <sub>(next day)</sub> ↔ Depressive symptoms <sub>(next day)</sub>	<b>-.316</b>	<b>.003</b>	<b>[-.521, -.105]</b>	<b>-.244</b>	<b>.025</b>	<b>[-.462, -.033]</b>
Meaning in life <sub>(next day)</sub> ↔ Depressive symptoms <sub>(next day)</sub>	-.209	.063	[-.429, .011]	-.202	.154	[-.483, .077]
Face-to-face interaction time ↔ Relationship	<b>.305</b>	<b>.005</b>	<b>[.092, .519]</b>	.191	.059	[-.008, .389]
Face-to-face interaction time ↔ Health conditions	-.043	.611	[-.205, .120]	.084	.391	[-.108, .276]
Face-to-face interaction time ↔ Education	-.367	.311	[-1.078, .344]	<b>-.228</b>	<b>.007</b>	<b>[-.393, -.062]</b>
Face-to-face interaction time ↔ Live	-.122	.313	[-.362, .114]	<b>-.269</b>	<b>.001</b>	<b>[-.425, -.113]</b>

## AGE, SOCIAL INTERACTIONS, AND WELL-BEING

alone

Face-to-face interaction time $\longleftrightarrow$ Backward digit span recall performance	.097	.394	[-.126, .320]	-.067	.564	[-.295, .161]
Virtual interaction time $\longleftrightarrow$ Relationship	<b>.329</b>	<b>.003</b>	<b> [.114, .543]</b>	.089	.183	[-.040, .218]
Virtual interaction time $\longleftrightarrow$ Health conditions	-.006	.958	[-.201, .192]	<b>.201</b>	<b>.034</b>	<b> [.015, .389]</b>
Virtual interaction time $\longleftrightarrow$ Education	.049	.325	[-.049, .157]	.069	.457	[-.114, .254]
Virtual interaction time $\longleftrightarrow$ Live alone	.108	.314	[-.108, .324]	-.031	.626	[-.167, .101]
Virtual interaction time $\longleftrightarrow$ Backward digit span recall performance	.038	.722	[-.171, .247]	.040	.638	[-.126, .206]
Relationship $\longleftrightarrow$ Health conditions	<b>.238</b>	<b>.048</b>	<b> [.000, .476]</b>	.128	.196	[-.067, .328]
Relationship $\longleftrightarrow$ Education	.084	.315	[-.084, .273]	<b>.203</b>	<b>.024</b>	<b> [.025, .376]</b>
Relationship $\longleftrightarrow$ Live alone	-.084	.315	[-.273, .084]	<b>-.668</b>	<b>&lt; .001</b>	<b> [-1.015, -.313]</b>
Relationship $\longleftrightarrow$ Backward digit span recall performance	-.025	.819	[-.238, .188]	-.050	.602	[-.238, .138]
Health conditions $\longleftrightarrow$ Education	.033	.338	[-.033, .099]	.172	.076	[-.016, .364]
Health conditions $\longleftrightarrow$ Live alone	-.034	.338	[-.102, .034]	-.085	.391	[-.275, .105]
Health conditions $\longleftrightarrow$ Backward digit span recall performance	.049	.581	[-.126, .222]	-.008	.938	[-.201, .185]
Education $\longleftrightarrow$ Live alone	.011	.476	[-.020, .042]	-.069	.469	[-.255, .117]
Education $\longleftrightarrow$ Backward digit span recall performance	-.105	.314	[-.303, .099]	.105	.275	[-.083, .293]

## AGE, SOCIAL INTERACTIONS, AND WELL-BEING

Live alone $\leftrightarrow$ Backward digit span recall performance	-.108	.314	[-.318, .102]	.132	.127	[-.038, .302]
Indirect effects						
Face-to-face interaction time $\rightarrow$ Sense of loneliness $\rightarrow$ Affective balance <sub>(next day)</sub>	.044	.552	[-.101, .182]	<b>.075</b>	<b>.001</b>	<b> [.030, .120]</b>
Face-to-face interaction time $\rightarrow$ Sense of loneliness $\rightarrow$ Meaning in life <sub>(next day)</sub>	.018	.561	[-.044, .082]	<b>.039</b>	<b>.012</b>	<b> [.008, .070]</b>
Face-to-face interaction time $\rightarrow$ Sense of loneliness $\rightarrow$ Depressive symptoms <sub>(next day)</sub>	-.054	.553	[-.239, .128]	<b>-.161</b>	<b>&lt; .001</b>	<b> [-.255, -.072]</b>
Virtual interaction time $\rightarrow$ Sense of loneliness $\rightarrow$ Affective balance <sub>(next day)</sub>	.002	.981	[-.086, .088]	.016	.402	[-.022, .056]
Virtual interaction time $\rightarrow$ Sense of loneliness $\rightarrow$ Meaning in life <sub>(next day)</sub>	.001	.981	[-.060, .061]	.008	.401	[-.011, .028]
Virtual interaction time $\rightarrow$ Sense of loneliness $\rightarrow$ Depressive symptoms <sub>(next day)</sub>	-.002	.981	[-.128, .125]	-.035	.407	[-.118, .048]

*Note.*  $n_{\text{Younger}} = 89$ ,  $k_{\text{Younger}} = 1,832$ ;  $n_{\text{Older}} = 102$ ,  $k_{\text{Older}} = 2,062$ . All estimates were standardized within the level. Statistically significant estimates ( $p < .05$ ) are bolded.

## AGE, SOCIAL INTERACTIONS, AND WELL-BEING

## Supplemental Table S3.

*Fit Indices of the Target Model and Alternative Models.*

Model	CFI	RMSEA	90% CI	SRMR <sub>within</sub>	SRMR <sub>between</sub>	AIC	BIC
Loneliness as the mediator (target)	.991	.035	[.009, .061]	.013	.012	51,884	53,075
Loneliness as the predictor (alternative 1)	.498	.150	[.139, .162]	.097	.077	52,656	53,772
Loneliness as the outcome (alternative 2)	.966	.054	[.037, .072]	.043	.033	51,924	53,090

*Note.* CFI = comparative fit index. RMSEA = root mean square error of approximation. SRMR = standardized root mean squared residual. AIC = Akaike information criterion. BIC = Bayesian information criterion. For alternative model 1, the model set-up was as follows: loneliness → interaction time → well-being. For alternative model 2, the model set-up was as follows: interaction time → well-being → loneliness. For non-nested model comparison, we consider models with lower AIC and BIC values having better fit with the data.