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Social Interactions and Physical Symptoms in Daily Life: Quality Matters for Older Adults, Quantity Matters for Younger Adults

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Abstract

Objective—The present study examined how the different attributes of daily social interactions (quality and quantity) were associated with physical health, and how these associations vary with age.

Method—Using an ecological momentary assessment approach, participants from an adulthood lifespan sample ($n = 172$; aged 20–79 years) reported their social interactions five times daily, and physical symptoms and symptom severity at the end of each day, for one week.

Main Outcome Measures—Number of physical symptoms and physical symptom severity.

Results—There was a within-person main effect of the quality (positivity), but not the quantity (frequency), of social interactions on the number of reported physical symptoms and their severity. Moderation analyses further revealed that the quality of daily social interactions predicted fewer physical symptoms for older adults, but not for younger adults; in contrast, the frequency of social interactions predicted less severe physical symptoms for younger adults, but not for older adults. Finally, the reported severity of physical symptoms predicted less frequent but more positive social interactions the next day.

Conclusion—Our findings point to the bidirectional associations between social interactions and health and highlight the importance of considering individuals developmental context in future research and interventions.

Keywords

social interaction; physical symptom; age; ecological momentary assessment; health

Introduction

It has long been recognized that social relationships have an important impact on physical health and mortality (e.g., House, Landis & Umberson, 1988). The influence of poor social relationships or lack of social integration on risk for mortality is comparable with or even

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greater than other well-established risk factors such as tobacco use, obesity, and excessive alcohol use (Holt-Lunstad, Smith & Layton, 2010). Moreover, there is increasing evidence that daily social interaction is one of the most important mechanisms through which social relationships influence physical health (Berkman, Glass, Brissette, & Seeman, 2000; Cohen, 2004). Research on daily social interactions provides valuable insight into adults' real-time access to companionship and social support, and can make important contributions to a better understanding of the daily processes linking social relationships and health (Cohen, 2004; Cornwell, 2011). In addition, previous theory and research suggest that particular attributes of social interactions might be especially influential for people at specific life stages based on their relevance for developmentally-significant social goals (Carmichael, Reis, & Duberstein, 2015; Carstensen, 1992; Luong, Charles, & Fingerman, 2011). Therefore, it is important to consider the developmental context for a better understanding of the influences of daily social interactions on health. Yet, research on daily social interactions remains relatively limited as it relates to lifespan processes. To fill this gap in the literature, the first aim of this study was to use ecological momentary assessments (EMAs) from an adulthood lifespan sample (age range = 20–79 years) to examine how social interactions influence individuals' physical health on a daily basis. We focused on the roles of two attributes of social interactions, the quality and quantity, which have been linked with various indicators of physical health including stress-related biological indices (Pauly, Lay, Nater, Scott, & Hoppmann, 2017), fatigue and pain (Bernstein, Zawadzki, Juth, Benfield, & Smyth, 2017), physiological function and a number of somatic symptoms (see Stadler, Snyder, Horn, Shrout, & Bolger, 2012 for a review). The second aim of this study was to examine how the influence of these two attributes of daily social interactions on physical health varies by age. Such work has important implications for health policy and real-time interventions that aim to promote health in people from different age groups.

Daily social interactions and physical health

As suggested by previous theory and research, social interactions may affect health through physiological, psychological, and behavioural pathways (e.g., Berkman et al., 2000; Umberson, Williams, Powers, Liu, & Needham, 2006). A growing number of studies using repeated assessments to capture daily social interactions in natural environments have found evidence to support the important role of social interactions in health. For example, both the quantity and quality of interactions with close partners predicted daily changes in blood pressure or cardiovascular risk, cortisol and testosterone levels, and a number of somatic symptoms including pain, tiredness and sleep (see Stadler et al., 2012 for a review). In addition, high quality daily social interactions were found to promote self-esteem, positive affect, and psychological well-being (Bernstein et al., 2017; Denissen, Penke, Schmitt, & van Aken, 2008), all of which in turn, have significant influences on health (Juth, Smyth, & Santuzzi, 2008). Daily social interactions also allow an individual to receive companionship and social support during times of stress, and thus attenuate both the psychological and physical responses to stress (Bajaj et al., 2016). Finally, daily social interactions may promote healthy behaviours. For example, when compared with their socially isolated counterparts, socially integrated individuals have been shown to engage in less frequent risky health behaviours such as smoking and excessive alcohol intake (Cohen & Lemay, 2007). Given these findings, we expect that both the quantity and the quality of social

interactions have positive influences on individuals' physical health as indicated by the total number and severity of somatic symptoms reported on a daily basis.

Daily social interactions, physical health and age

Most previous studies have not considered the possibility of age differences in the consequences of social interactions. However, there are several reasons to expect that the influence of social interactions on physical health varies by age and, more importantly, that different attributes of social interactions such as quantity and quality of social interactions are particularly influential during specific life stages. First, life span development theories suggest that achieving developmentally-relevant social goals at different life stages is advantageous for social and psychological adaptation and well-being (Carmichael et al., 2015), which in turn, promote physical health (see Chida & Steptoe, 2008 for a review). Specifically, Socioemotional Selectivity Theory (SST, Carstensen, 1992) posits that expansive goals such as acquiring knowledge or making new social contacts are particularly salient during early adulthood when time is typically perceived as expansive. Frequent interactions with a variety of partners can offer access to different information and help young adults to develop social skills and self-knowledge, and thus are particularly influential for younger adults' psychological adaptation and well-being (Carmichael et al., 2015). For older adults, on the other hand, the quality rather than quantity of social interactions should be more influential for psychological adaptation and well-being because high quality interactions (rather than more frequent interactions) are more likely to foster emotional closeness which is an important social goal for older adults (Carstensen, 1992). In line with this idea, frequency of social contact has been observed to correlate negatively with loneliness in young and middle-aged adults but not in older adults, whereas the quality of network relationships was negatively correlated with loneliness for middle-aged and older adults but not for younger adults (Victor & Young, 2012).

A second reason that effects of daily social interactions on physical health may differ by age is that interpersonal conflicts or distress may be more costly for older (vs. younger) adults' health because of the increasing physiological vulnerability with age. Specifically, the Strength and Vulnerability Integration Model (SAVI; Charles & Luong, 2013) posits that aging is associated with increasing physiological vulnerabilities that make it more difficult to regulate high levels of emotional arousal. In situations characterized by a high level of distress, the physiological consequences of sustained emotional arousal are more costly for older adults. For example, after a stressor, older adults show greater immunological impairments, greater blood pressure reactivity, and slower recovery to baseline status relative to younger adults (Ong, Rothstein, & Uchino, 2012). In addition, chronic conditions that become more common with age may contribute to biological vulnerability in the face of stress among older adults (Umberson et al., 2006). Accordingly, negative social interactions should have stronger adverse effects on the health of older adults than younger adults. In line with this idea, previous longitudinal studies have found that the adverse effect of marital strain on self-reported health or cardiovascular risk was greater at older ages (Liu & Waite, 2014; Umberson et al., 2006). Given older adults' preference for quality over quantity in their daily social interactions (Carstensen, 1992), the low frequency of social interactions may be less likely to lead to distress and poorer health for older adults relative to younger

adults. For example, previous research found that being alone (vs. being with others) was not related to worse mood among older adults, and in fact, was associated with a greater sense of control over their activity (Larson, Zuzanek, & Mannell, 1985).

The current study

Despite the growing numbers of EMA studies on daily social interactions and health, little is known about how the different attributes of daily social interactions are associated with physical health, and how these associations vary with age. The current study aimed to investigate how, within individuals, fluctuations in social interaction quantity and quality relate to physical symptoms. Specifically, we examined whether the within-person associations between different features of social interactions (i.e., quantity and quality) and physical symptoms differ for younger versus older adults as predicted by life span theories (Carstensen, 1992; Charles & Luong, 2013). By collecting repeated assessments in near real-time and in natural settings, we were able to capture multiple social interactions for participants each day with higher accuracy and greater ecological validity over more traditional methods such as an experimental method or retrospective global measures (Bernstein et al., 2017). The repeated assessments approach also enabled us to differentiate and compare the within-person and between-person associations between social interactions and physical symptoms, and to test the temporal order in cross-lagged analyses (Smyth, Juth, Ma, & Sliwinski, 2017). Based on theories and previous research, we hypothesized that individuals would report fewer physical symptoms and less severe physical symptoms on days when they engaged in more (vs. less) social interactions (H1a) and when social interactions were perceived as high (vs. low) quality (H1b). We further predicted that the within-person association between the quantity of daily social interactions and physical symptoms and severity would be weaker for older adults relative to younger adults (H2a) and that the within-person association between social interaction quality and physical symptoms and severity would be stronger for older adults relative to younger adults (H2b). We based this hypothesis on age-related changes in social motivations as predicted by SST, and age-related increases in physiological vulnerability in the face of stress as predicted by SAVI. In addition, we explored whether the experience of physical symptoms was associated with subsequent social interactions, as well as whether the potential bidirectional associations between social interactions and physical symptoms can extend across days.

Method

Participants

The present study utilized data from the ecological momentary assessment (EMA) portion of the first burst of a larger measurement burst study of cognition, health, and aging across the lifespan, approved by the Institutional Review Board of the university (see Mogle, Munoz, Hill, Smyth & Sliwinski, 2017 for additional details). Potential participants for the larger study ($N = 214$) were recruited from community-dwelling adults in central New York state via a diverse array of advertisements. Eligibility requirements for the study included age (20 to 80 years old), fluency in English, physical ability to operate a palm top computer, and absence of major cognitive impairment. Of the 214 participants initially recruited, 22 were not eligible and 12 were no longer interested after receiving the information on the study

protocol. In addition, eight participants did not complete at least one beep and one evening assessments during the EMA portion of the study and thus were excluded from analyses. Thus, the final sample for the present study included 172 participants (48% men). Participants in the final sample ranged in age from 20 to 79 years old ($M = 49.41$, $SD = 16.96$), and 58% of them self-identified as Caucasian, 31% as African American, 3.5% as Hispanic and 7.5% as others. About 74% of the participants had a high school degree or less and 26% had a bachelor or graduate school degree. Approximately 42% of the participants were employed and the whole sample reported an average annual income of \$23,599. Twenty-nine percent of the participants were currently married at the time of participation.

Procedure

Participants completed two face-to-face sessions in a research laboratory and 7 days of EMA assessments using a provided mobile device (palmtop computer with functionality limited to the study protocol). Following the initial phone-screening, eligible participants completed the consent process, a demographics questionnaire, training in the use of the mobile device in the lab session and then a 2-day pre-screening study to practice and habituate to the EMA protocol. Eligible participants were asked to carry the mobile device with them for seven consecutive days. Each day, participants completed a morning assessment, an evening assessment and up to five randomly beeped momentary assessments which were scheduled for pseudo-random times spaced approximately 2–3 hours apart throughout the day. Based on previous research as well as our own work (Bernstein et al., 2017; Smyth, Juth, Ma, & Sliwinski, 2017), this schedule of momentary assessments per day could maximize the accuracy and the sufficiency of the data that we could collect from participants without significantly interfering with their daily lives or increasing their participation burden. After the EMA session, participants returned to the lab for a series of cognitive tests, and were debriefed and compensated for their participation. The participants were compensated up to \$100 for their participation in this study (\$50 for two lab sessions and \$50 for the EMA session).

This study used data from the beeped and evening assessments. Out of a potential 6020 beeped momentary assessments ($172 \text{ individuals} \times 7 \text{ days} \times 5 \text{ beeped assessments per day}$), a total of 5414 momentary assessments were completed (90%); and out of a potential 1204 evening assessments ($172 \text{ individuals} \times 7 \text{ days}$), a total of 1053 evening assessments were completed (87%). At the person level, each participant completed on average 31 ($SD = 5.89$, $Range = 5\text{--}35$) momentary assessments and six ($SD = 1.39$, $Range = 1\text{--}7$) evening assessments over the 7-day study period. About 92% of the participants ($N = 158$) completed at least 4 evening assessments and 21 momentary assessments over the 7-day study period (about 60% of all potential assessments). Missing data analyses suggested that the missingness was not associated with any demographic variables or participants' overall physical health. Sensitivity analyses further suggested that excluding participants who did not complete at least 4 evening assessments and 21 momentary assessments ($N = 14$) from analyses did not change any results.

Measures

Momentary assessment

Social interaction frequency: Participants' social interaction frequency was assessed by one item at each momentary assessment (Zhaoyang, Sliwinski, Martire, & Smyth, 2018): *'Since the last assessment, how many social interactions have you had?'* Participants were carefully trained at baseline, and reminded in the EMA report, that a social interaction is defined as talking to someone in person, by phone, or online, and were asked to select a number from 0 to 10 (0 = *None*, 10 = *10 or more social interactions*).

Social interaction quality: At each momentary assessment, participants rated the quality of their *most recent* social interaction on two items (Bernstein et al., 2017; Zhaoyang et al., 2018): *'Overall, how pleasant or positive was this interaction?'* and *'Overall, how unpleasant or negative was this interaction?'* Each item was scored on a 7-point scale respectively (1 = *Not at all*, 7 = *Extremely*). As expected, the positive rating and negative rating were correlated at both within- and between-person levels ($r = -.56$ and $r = -.46$, respectively). Previous studies using similar items suggested that positive and negative social interaction items were best treated as separate constructs rather than two ends of a continuous dimension (e.g., Cundiff, Kamarck, Manuck, 2016; Joseph, Kamarck, Muldoon, 2014). Therefore we assessed social interaction quality by positive and negative ratings separately. Participants who reported zero social interactions since the last momentary assessment did not answer the follow-up questions about interaction quality but were asked a different set of follow-up questions (e.g., reasons for no social interactions, expectations of future social interactions; matched on length to the social interaction quality questions) to equate the response burden and avoid entraining particular response styles.

Evening assessment

Physical symptoms: Physical symptoms were measured with a modified version of a symptom checklist (Almeida, Wethington & Kessler, 2002; Larsen & Kasimatis, 1991). The modified version of symptom checklist (Almeida et al., 2002) dropped the items assessing psychological or psychosomatic symptoms (e.g., cry or urge to cry, nervousness, temper outbursts) and only included items on physical symptoms, and thus is more appropriate for the the current study. Our final list contained the following 18 physical symptoms: headache, backache, joint pain, dizziness, nausea, allergy symptoms, poor appetite, congestion, sore throat, muscle soreness, cold/flu, chest pain or tightness, constipation/diarrhoea, trouble breathing, heart pounding, hot or cold flashes, trembling/shaking, other symptoms. Each evening, participants were asked to report if they had experienced each of the symptoms that day from the list. A variable was created to indicate the total number of symptoms a participant reported per day, ranging from 0 (no symptom checked) to 18 (all symptoms checked). For each selected symptom, a follow-up question was asked to measure symptom-specific severity: *Overall, how bad was your [symptom] today* (1 = *Not at all*, 7 = *Extremely*)? Participant's severity ratings on all reported symptoms were averaged to produce a mean score, indicating the overall severity of all reported symptoms. Participants who selected no symptom did not answer this follow-up question, but again were asked

different follow-up questions (e.g., reasons for no physical symptoms) to equate the response burden.

Baseline covariates—Demographic variables were measured at the baseline lab assessment and were coded as follows: gender (0=*Male*, 1=*Female*), race (0 = *non-White*, 1=*White*), education (*How many years of education have you received?*), employment status (0 = *Not working*, 1= *Working for payment*), and marital status (0 = *Not married*, 1 = *Currently married*). Results of a principal component analysis including education, employment status, and income revealed that all three indices of socioeconomic status (SES) loaded on one common factor (i.e., only 1 eigenvalue was greater than 1, greater than 55 % of variance explained, and all loadings were greater than .53). Hence, income, education, and employment status were standardized and then aggregated to form a composite SES score for each individual, which was then used as a covariate. We also measured participants' overall physical health at baseline by one item adapted from the Cantril Self-Anchoring Striving Scale (Cantril, 1965): '*Now, thinking about your physical health, and a ladder with steps numbered from 0 to 10, where 0 represents the worst possible health, and 10 means the best possible health, on which step of the ladder is your physical health today?*' Previous studies indicate that a simple, one item self-report of health status is as powerful a predictor of functional ability or mortality as more detailed health status indicators (Idler & Angel, 1990; Idler & Kasl, 1995).

Analytic strategy

Multilevel modelling was used to examine the associations between social interactions and physical symptoms (Singer & Willett, 2003). The data were structured hierarchically, with daily assessments (level 1) nested within persons (level 2). Thus, social interaction and physical symptoms could vary over days within a person as well as across persons. All analyses were conducted using SAS PROC MIXED with restricted maximum likelihood (REML) and robust standard errors (Maas & Hox, 2004). We conducted analyses in a series of steps. First, an empty model with a random intercept but no predictor was tested for each key variable to estimate the variance at different levels. Second, the within-day associations between social interactions throughout the day and physical symptoms reported at the end of the day were examined in a set of models (Model 1). In each model, predictors included a level 1 person-mean centred social interaction variable which captures each person's daily deviation from his or her own mean score of social interactions (within-person effect, WP) and a level 2 mean score of social interactions which captures the individual differences in the average score of social interactions (between-person effect, BP). Third, we added the cross-level interaction between age and each level 1 person-mean centred social interaction variable in the model (Model 2). For every significant cross-level interaction, we estimated the region of significance, which delineates the age range in which the associations between a social interaction variable and a physical symptom variable are significant. In addition to within-day analysis, we also examined the cross-day lagged effect of social interaction by predicting physical symptoms at the end of day t from social interactions that occurred throughout day $(t-1)$. In order to differentiate and account for the concurrent effect, social interactions occurred throughout day t were also included in the model. Finally, we tested the potential bidirectional associations between social interactions

and physical symptoms by predicting social interactions from the previous night's physical symptoms. The potential moderation effects of age were also tested in all cross-day analyses. The continuous age variable was used in all analyses.

In all models, we controlled for time-related covariates (i.e., whether it was a workday or not) and person level covariates (i.e., age, gender, race, marital status, SES, and general physical health) that were suggested by previous research as correlates of social interactions, physical symptoms or both (Bernstein et al., 2017). In addition, we made the following modelling decisions. First, a random intercept was included to allow the mean score of physical symptoms to vary across individuals, and a random slope of the within-person effect of social interaction was also included if it was statistically significant to allow the association between daily social interaction and physical symptoms to vary between individuals. All level-1 variables were person-mean centred and all level-2 variables were grand-mean centred. Finally, because the variable count of physical symptoms was positively skewed with many zeros, all analyses using this variable as the outcome were repeated by estimating an over-dispersed Poisson model and a zero-inflated Poisson model (ZIP, Atkins, Baldwin, Zheng, Gallop & Neighbors, 2013). The results remained unchanged and thus were reported as standard multilevel models.

Results

Preliminary analyses

Participants in this sample, on average, reported 1.16 symptoms per day ($SD=1.14$, $Range = 0-6$). Backache, joint pain, muscle soreness and headache were the most frequent symptoms (daily frequency: backache = 0.23, joint pain = 0.20, muscle soreness = 0.11, headache=0.10). In addition, 16% of participants ($N=28$) did not report any symptoms across 7 days. The average score on symptom severity was below mid-point ($Ms = 3.55$). The intraclass correlation (ICC) for the count of symptoms and symptom severity was 0.63 and 0.59 respectively, suggesting that the within-person source of variation accounted for 37% to 41% of the total variability in daily symptoms and severity. As shown in Table 1, the ICCs of daily social interaction variables revealed that approximately 36% to 59% of the total variance of social interactions occurred at the within-person level. These results suggested that participants experienced substantial day-to-day fluctuations in their social interactions and physical symptoms.

The intercorrelations of the daily social interaction and physical symptom variables suggested that, at the within-person level, higher social interaction quality (i.e., higher positivity and lower negativity) was associated with fewer physical symptoms and lower level of symptoms severity, whereas social interaction frequency was not associated with any physical symptom variable. At the between-person level, less frequent and more negative daily social interaction were associated with severer symptoms (Table 1).

Daily social interactions and physical symptoms

First, we examined the hypothesis that participants would report fewer physical symptoms and less severe physical symptoms on days when they engaged in more frequent (vs. less

frequent) social interactions (H1a). As shown in Table 2 (Model 1), contrary to our hypothesis, social interaction frequency did not have a significant within-person association with either the number of physical symptoms or the severity of reported physical symptoms. A significant between-person association was found between social interaction frequency and the numbers of reported physical symptoms. Surprisingly, individuals who typically (i.e., on average) engaged in more frequent daily social interactions reported more physical symptoms than their counterparts who engaged in less frequent daily social interactions.

We then examined the hypothesis that participants would report fewer physical symptoms and less severe physical symptoms on days when they perceived social interactions as high (vs. low) quality (H1b). In line with our predictions, results indicated that social interaction positivity (within-person) was associated with both fewer and less severe physical symptoms (Table 3, Model 1). That is, on days when participants perceived their social interactions throughout the day as more positive, they reported (at the end of the day) fewer physical symptoms and rated these symptoms as less severe than days when they perceived their social interactions as less positive. Within-person variability in social interaction negativity, however, was not significantly related to the number of physical symptoms or symptom severity. However, between-person differences in social interaction negativity were significantly associated to the number of reported physical symptoms. That is, participants who perceived their social interactions as more negative reported more physical symptoms in general compared with those who perceived their social interactions as less negative. In contrast, between-person differences in social interaction positivity were unrelated to symptom variables.

We also tested models that examined the predictive effects of social interaction frequency, positivity and negativity simultaneously. All of the significant effects reported above remained the same, supporting the unique contribution of each predictor beyond the effects of the other social interaction variables.

Age differences in the associations between daily social interactions and physical symptoms

We then tested whether age moderated the within-person association between social interaction frequency and physical symptoms in order to determine if this association was weaker for older adults than for younger adults (H2a). In line with our prediction, age $\times$ social interaction frequency significantly predicted symptom severity (Table 2, Model 2), and greater age was associated with weaker associations between social interaction frequency and the severity of physical symptoms (Figure 1). Region of significance analysis further indicated that the association between social interaction frequency and severity of physical symptoms was significant for adults aged 49 years and below. That is, people 49 years and younger reported their physical symptoms as less severe on days when they engaged in more frequent social interactions compared with days when they engaged in less frequent social interactions. For people aged 50 years old or older, however, social interaction frequency throughout the day was not significantly associated with their symptom severity at the end of the day.

We then tested whether the within-person association between social interaction quality and physical symptoms was stronger for older adults than for younger adults (H2b). In line with our prediction, age significantly moderated the within-person association between the quality of social interactions (positivity and negativity) and the number of reported physical symptoms (Table 3, Model 2). Greater age was associated with stronger associations between social interaction quality (positivity and negativity) and the number of reported physical symptoms (Figure 2). Region of significance analysis further indicated that the association between social interaction positivity and number of physical symptoms was significant for adults aged 42 years and above whereas the association between social interaction negativity and number of physical symptoms was significant for adults aged 47 years and above. Middle-aged and older adults thus report fewer physical symptoms on days when they perceive their social interactions throughout the day as high quality (higher positivity and lower negativity) compared with days when they perceive their social interactions as low quality (lower positivity and higher negativity). For younger adults, however, social interaction quality throughout the day was not significantly associated with the number of physical symptoms they reported at the end of the day.

We next explored the cross-day lagged effects of social interactions in day t on physical symptoms and severity reported at the end of day $t+1$ controlling for social interactions in day $t+1$, and found no significant lagged effects. In addition, age did not significantly moderate any of the lagged effects of social interactions. Finally, we examined whether physical symptoms or severity have an influence on the next day's social interactions. We found that the severity of physical symptoms today marginally significantly predicted the next day's social interaction frequency ($b = -0.14$, $p = .081$). That is, if participants perceived their physical symptoms as more severe today they engaged in less frequent social interactions tomorrow. In addition, the severity of physical symptoms significantly predicted the next day's social interaction positivity ($b = 0.12$, $p = .006$). That is, if participants perceived their physical symptoms as more severe tonight, they reported their social interactions as more pleasant tomorrow. These effects remained significant even after controlling for today's social interaction, ruling out potential carry-over effects of social interactions across days. Again, age did not significantly moderate the lagged effects of physical symptoms. Together, the results from the lagged analyses indicate that social interactions did not have cross-day lagged effects on physical symptoms; however, the severity of physical symptoms predicted less frequent but more positive social interactions the next day.

Discussion

A better understanding of the role of social interactions in physical health requires explicit attention to the specific characteristics of social interactions and individuals' social environment (Cohen, 2004). The present study highlights the importance of developmental context in understanding the influences of different attributes of social interactions on physical health. Particular, we examined how the quantity and quality of social interactions throughout the day were associated with physical symptoms at the end of the day, and how these associations varied with age. We found that the frequency of social interactions predicted less severe physical symptoms for younger adults, but not for older adults; in

contrast, the quality of social interactions (higher positivity and lower negativity) predicted fewer physical symptoms for older adults, but not for younger adults. Overall these results are consistent with our hypotheses that having a large quantity of social interactions is more important for younger adults' daily health, whereas having high quality social interactions is more important for older adults' health. According to lifespan theories, frequent interactions with a variety of partners offer opportunities for young adults to achieve their chief social goal--acquiring more knowledge and information, and thus having positive effects on young adults' adaptation and well-being (Carstensen, 1992). Older adults, on the other hand, are more likely to be influenced by interaction quality due to their preference of emotional closeness during social interactions and their physiological vulnerabilities to interpersonal distress (Carstensen, 1992; Charles & Luong, 2013). Our findings are in line with previous longitudinal research which has shown that the protective effect of positive marital interactions on the cardiovascular system were more pronounced among older (vs. younger) adults (Liu & Waite, 2014). Moreover, prior EMA research found that younger adults have higher cortisol when alone than when with others, but that this effect was not observed in older adults (Pauly et al., 2017). It is worth noting that, although the within-person effects observed in our study were small in magnitude (e.g., a 1-point increase in social interaction frequency on a given day was associated with a decrease of 0.12 points in younger adults' severity of physical symptom [7-point scale] on that day), the observed effect sizes are similar to what has been observed in previous studies (Bernstein et al., 2017; Pauly et al., 2017). Given the frequency of social interactions in daily life, it is plausible that these small effects of daily social interactions, when accumulated over time, could have long-term health implications.

We also find some limited evidence supporting the bidirectional associations between social interactions and physical symptoms. Specifically, the severity of physical symptoms one day predicted less frequent but more positive social interactions the next day. One explanation is that health issues, especially ones that are associated with functional limitations, reduce opportunities for social interactions in daily life (Packham & Hall, 2002). Also, health issues may limit the social interactions to certain type of partners such as spouse, family and caregivers, who are more likely to provide comfort and support. However, these results may also reflect active coping strategies. That is, when people are not feeling well, they may choose to only interact with close partners who are more likely to provide positive experiences (Walen & Lachman, 2000). Regardless of the underlying motivations, our results are consistent with a dynamic process whereby daily social interactions predict physical health, which in turn shape subsequent social interactions.

Another interesting finding of our study is that the positivity and negativity of social interactions affected physical symptoms in different ways. The positivity of social interactions exhibited its effects on physical symptoms at the within-person, day-to-day level whereas the negativity of social interactions had between-person effects on physical symptoms. Our finding is in line with a previous diary study that found associations between daily positive interpersonal events and lower inflammatory markers (Sin, Graham-Engeland, & Almeida, 2015), indicating the uplifting effects of positive social interactions on health on a daily basis. However, such evidence does not diminish the potential detrimental influences of negative social interactions on health. The between-person effects of negative social

interactions in our study demonstrated that individuals who perceived more negativity in their social interactions in general (based on the averaged reports over a week) reported more physical symptoms than their counterparts. It suggests that the influences of negative social interactions on health may unfold over a longer time scale compared with positive social interactions (e.g., over a week vs. a day), possibly due to rumination processes (McCullough, Orsulak, Brandon, & Akers, 2007) or the cumulative effects of negativity experienced every day. Moreover, previous research suggests that positive and negative components of social interaction may have distinct physiological mechanisms and thus have different health consequences (see Brooks & Schetter, 2011 for a review). Our findings, together with a growing literature (see Rook, 2015 for a review), highlight the need to attend to both the positive and negative aspects of social interactions in order to gain a more complete picture of how social relationships influence health and well-being.

A surprising finding from our study was the positive between-person effect of social interaction frequency on the number of physical symptoms. That is, people who had more frequent social interactions in general reported more physical symptoms than their counterparts who had less frequent social interactions. One possible explanation is that more frequent social interactions require more time and effort, and may also increase the chance of having unpleasant encounters or interpersonal conflicts, which could lead to more stress. In addition, there is evidence from previous research that frequent social interactions may increase exposure to ailments that are transmitted via social contact, such as upper respiratory or urinary-sexual infections, or causing more pain and aches (Reis, Wheeler, Kernis, Spiegel, & Nezlek, 1985).

The findings from our study may also help inform theory and/or have clinical implications. Our findings provide evidence consistent with life span theories that emphasize the importance of considering developmental context in understanding the association between different aspects of social interactions and health. Our study differentiates the effects of the quantity versus quality, positivity versus negativity of social interactions on health, and points to the potential contextual conditions (e.g., developmental context, time scales) that may explain the relative importance of each aspects of social interactions. More speculatively, our findings also point to the possibility that efforts (including interventions) designed to improve people's health by enhancing the quantity or quality of their daily social interactions should be based on people's developmental stage and goals. For example, interventions that encourage more frequent or varied social interactions may be more beneficial for younger adults than for older adults. For older adults, on the other hand, interventions designed to enhance psychosocial resources or skills to improve emotional closeness with intimate partners, or to cope with the intimate relationship loss or disruption, may provide more health benefits (Carmichael et al., 2015) given the importance of the quality of social interactions at this life stage.

There are limitations of the current study that present promising avenues for future research. First, social interaction was defined as "talking to someone in person, by phone, or online" in our study, and thus our results did not differentiate the effects of social interactions via different channels. Some studies find that online social contacts were not an effective alternative for offline social interactions in reducing feelings of loneliness (Yao & Zhong,

2014). Future research is needed to distinguish between the effects of online and ersatz social interactions, and if any such differences between types of social interaction (virtual versus face-to-face) are consistent across people of different ages. In addition, our measurement of social interactions did not request or assess the duration of each reported interaction. It is possible that social interactions that have lasted for a certain period of time (e.g., 10 min) would be more meaningful and influential for health than would short encounters. Also, our study did not assess the specific content or domains of social interactions, precluding tests of distinct effects of different types of social interactions (e.g., rejection, neglect, or unsympathetic behaviours) on health outcomes.

Second, physical symptoms were assessed by self-report measures in our study and the accuracy and validity of the data may be influenced by recall bias or situational factors. More objective assessments of physical health are needed for future research. Third, the data in our study were cross-sectional in nature and thus we cannot unambiguously infer that the age differences were solely due to developmental processes, but not other cohort differences. In addition, we used a convenience sample which is subject to selection bias and is impossible to estimate the nonresponse rate in the population. Finally, our study did not test the pathways through which social interactions affect physical symptoms, and whether different mechanisms may account for the effects of social interactions for people with different characteristics, such as age, gender and personality. Particularly, health behaviours (e.g., diet, exercise, medical treatments adherence), psychological (e.g., self-esteem, emotional responses and regulation) and physiological pathways (e.g., cardiovascular reactivity, immune system function) have been identified as important mechanisms through which social relationships could influence health (Berkman et al., 2010). It is a promising route for future research to examine function of these processes in daily life.

In conclusion, the current study contributes to our understanding of the associations between the quality and quantity of ecologically valid social interactions and self-reported physical health in daily life. Our findings are consistent with the view that the *quantity* of social interactions is more influential for younger adults' health whereas the *quality* of social interactions is more influential for older adults' health. These findings highlight the importance of considering individuals' developmental context for future theory, research, and interventions that aim to understand and/or improve social interactions and health.

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Figure 1.

Illustrations of two-way interactions between daily social interaction frequency and age on the severity of physical symptoms reported at the end of the day. For younger, middle and older age, mean - 1 SD (32 years), mean (49 years) and mean + 1 SD (66 years) are shown for illustrative purposes only. b = Unstandardized coefficient of simple slope. +p < .10. * p < 0.05

Figure 2.

Illustrations of two-way interactions between daily social interaction quality (positive A, negative B) and age on numbers of physical symptoms reported at the end of the day. For younger, middle and older age, mean – 1 SD (32 years), mean (49 years) and mean + 1 SD (66 years) are shown for illustrative purposes only. b = Unstandardized coefficient of simple slope.

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table 1

Correlations and Variable Statistics for Daily Social Interaction and Physical Symptom Variables.

	Num. of Symptoms	Symptoms Severity	SI Frequency	SI Positivity	SI Negativity
Correlations					
Num. of Symptoms	--	.34 ***	.05	-.08	.15
Symptoms Severity	.17 ***	--	-.18 *	-.11	.18 *
SI Frequency	-.02	-.03	--	.15 *	-.05
SI Positivity	-.11 ***	-.12 **	.02	--	-.40 ***
SI Negativity	.08 *	.09 *	-.03	-.56 ***	--
Statistics					
Mean	1.16	3.55	2.44	5.16	1.91
SD	1.14	1.07	1.76	0.84	0.75
Possible Range	0–18	1–7	0–10	1–7	1–7
ICC	.63	.59	.64	.48	.41

Note. SI-Social interaction, SD-Standard deviation, ICC- Intraclass correlation. Within-person correlations are below the diagonal and between-person correlations are above the diagonal. Mean and SD were computed based on person-level aggregated variables.

*
 $p < .05$.

**
 $p < .01$.

 $p < .001$.

Table 2

Results from Multilevel Models Predicting Physical Symptom and Symptom Severity from Daily Social Interaction Frequency and Age.

	Num. of Symptoms		Symptoms Severity	
	Model 1	Model 2	Model 1	Model 2
	<i>Est. (S.E.)</i>	<i>Est. (S.E.)</i>	<i>Est. (S.E.)</i>	<i>Est. (S.E.)</i>
Fixed effects				
Intercept	0.57 ** (0.18)	0.57 ** (0.18)	3.74 *** (0.23)	3.73 *** (0.23)
Age	0.01 * (0.01)	0.01 * (0.01)	0.004 (0.01)	0.004 (0.01)
Women	0.13 (0.18)	0.13 (0.18)	-0.16 (0.17)	-0.17 (0.17)
White	0.58 ** (0.19)	0.58 ** (0.19)	0.15 (0.18)	0.16 (0.16)
SES	-0.27 * (0.12)	-0.27 * (0.12)	-0.39 ** (0.14)	-0.40 *** (0.13)
Married	-0.55 ** (0.21)	-0.55 ** (0.21)	-0.13 (0.20)	-0.13 (0.20)
Overall physical health	-0.14 *** (0.04)	-0.14 ** (0.04)	-0.05 (0.04)	-0.05 (0.04)
Workday	0.18 ** (0.06)	0.18 ** (0.06)	0.04 (0.10)	-0.05 (0.10)
SI Frequency (BP)	0.10 * (0.05)	0.10 * (0.05)	-0.07 (0.05)	-0.07 (0.05)
SI Frequency (WP)	-0.02 (0.02)	-0.02 (0.02)	-0.04 (0.03)	-0.06 (0.03)
SI Frequency(WP) × Age		0.0002 (0.001)		0.004 * (0.002)
Variance				
BP Variance	1.04 *** (0.13)	1.04 *** (0.13)	0.71 *** (0.12)	0.70 *** (0.12)
WP Variance	0.65 *** (0.03)	0.65 *** (0.03)	0.60 *** (0.04)	0.60 *** (0.04)

Note. Est-estimates of unstandardized regression coefficient, S.E.-standard error, SI-social interaction, SES-socioeconomic status, WP-within-person, BP-between-person.

*
 $p < .05$.

**
 $p < .01$.

 $p < .001$.

Table 3

Results from Multilevel Models Predicting Physical Symptom and Symptom Severity from Daily Social Interaction Quality (Positivity and Negativity) and Age.

	Num. of Symptoms		Symptoms Severity	
	Model 1	Model 2	Model 1	Model 2
	<i>Est. (S.E.)</i>	<i>Est. (S.E.)</i>	<i>Est. (S.E.)</i>	<i>Est. (S.E.)</i>
Fixed effects				
Intercept	1.41 (0.63)	1.41 * (0.63)	3.99 *** (0.63)	4.02 *** (0.63)
Age	0.01 ** (0.01)	0.01 ** (0.01)	0.003 (0.01)	0.003 (0.01)
Women	0.22 (0.19)	0.22 (0.19)	-0.16 (0.17)	-0.15 (0.17)
White	0.49 * (0.20)	0.50 * (0.20)	0.17 (0.18)	0.17 (0.18)
SES	-0.21 (0.12)	-0.21 (0.12)	-0.43 *** (0.13)	-0.43 *** (0.13)
Married	-0.47 * (0.21)	-0.47 * (0.21)	-0.18 (0.20)	-0.18 (0.20)
Overall physical health	-0.13 ** (0.04)	-0.13 ** (0.04)	-0.05 (0.03)	-0.06 (0.03)
Workday	0.15 * (0.07)	0.14 * (0.07)	0.01 (0.10)	0.01 (0.10)
SI positivity (BP)	-0.11 (0.11)	-0.11 (0.11)	-0.08 (0.12)	-0.08 (0.12)
SI positivity (WP)	-0.12 * (0.05)	-0.15 ** (0.05)	-0.13 ** (0.04)	-0.13 ** (0.04)
SI positivity (WP) × Age		-0.01 ** (0.002)		0.004 (0.002)
Variance				
BP Variance	1.05 *** (0.14)	1.05 *** (0.14)	0.70 *** (0.12)	0.70 *** (0.12)
WP Variance	0.64 *** (0.03)	0.64 *** (0.03)	0.58 *** (0.04)	0.58 *** (0.04)
Fixed Effect				
Intercept	0.30 (0.26)	0.30 (0.26)	3.26 *** (0.31)	3.25 *** (0.30)
Age	0.02 ** (0.01)	0.02 ** (0.01)	0.005 (0.01)	0.01 (0.01)
Women	0.24 (0.17)	0.24 (0.17)	-0.13 (0.17)	-0.13 (0.17)
White	0.45 * (0.20)	0.45 * (0.20)	0.15 (0.18)	0.15 (0.18)
SES	-0.20 (0.12)	-0.20 (0.12)	-0.43 *** (0.13)	-0.43 *** (0.13)
Married	-0.47 * (0.21)	-0.47 * (0.21)	-0.19 (0.20)	-0.19 (0.19)
Overall physical health	-0.13 ** (0.04)	-0.13 ** (0.04)	-0.05 (0.03)	-0.05 (0.04)
Workday	0.17 ** (0.06)	0.17 ** (0.06)	0.01 (0.10)	0.01 (0.10)
SI negativity (BP)	0.27 * (0.12)	0.27 * (0.12)	-0.17 (0.14)	-0.17 (0.14)
SI negativity (WP)	0.08 (0.05)	0.10 * (0.05)	0.10 (0.05)	0.09 (0.05)
SI negativity (WP) × Age		0.005 * (0.002)		-0.005 (0.003)
Variance				
BP Variance	1.02 *** (0.13)	1.02 *** (0.13)	0.68 *** (0.12)	0.68 *** (0.11)
WP Variance	0.65 *** (0.03)	0.65 *** (0.03)	0.59 *** (0.04)	0.59 *** (0.04)

Note. Est-estimates of unstandardized regression coefficient, S.E.-standard error, SI-social interaction, SES-socioeconomic status, WP-within-person, BP-between-person.

*
 $p < .05$.

**
 $p < .01$.

 $p < .001$.

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