

The Role of Social Interactions in Different Modalities for Well-Being and Health in Older Adults' Daily Lives

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Strange how a phone call can change your day

Take you away

Away from the feeling of being alone

Bless the telephone

Labi Siffre, "*Bless the Telephone*" (1971)

Abstract

This dissertation focuses on how social interactions in different modalities are associated with well-being and health in older adults' daily lives. Social connectedness plays a crucial role in well-being and health, yet differences in the effects of social interactions across different modalities among older adults remain understudied. Thus, the aim of this dissertation was to investigate the role that interaction modalities play in the association between social interactions and well-being, with special emphasis on modalities that are not in-person. Study I examined how weekly frequency of social interactions in four different modalities (face-to-face, video-call, telephone, text-based digital) was associated with positive and negative affect and loneliness in Swiss older adults during the COVID-19 pandemic. Study II expanded on these results by investigating how daily frequency of social interactions in three different modalities (face-to-face, telephone, text-based digital) could buffer adverse effects of poor health on daily well-being outcomes in Swiss older adults. Study III used data from Canadian older adults in dyads and examined how convergence in partner reports about time spent with one another (face-to-face and digital) was associated with daily well-being during the COVID-19 pandemic. All three studies support the claim that more social interactions are associated with better well-being, and that face-to-face interactions are most consistently associated with enhanced well-being. However, results from Studies I and II suggest that social interactions in other modalities are also positively associated with well-being, especially when face-to-face contact is rare or participants experience their health as worse than usual. Results from Study I show that digital social interactions might compensate for a lack of face-to-face interactions. Results from Study II indicate that participants with more digital interactions showed a weaker negative relationship between poor health and well-being. Results from Study III suggest that being aligned with one's interaction partner regarding the perceived length of interaction is not as important for the individual's well-being as hypothesized. Comparing the design and results from the three studies suggests that measuring social interactions by their frequency of occurrence rather than their estimated duration might be better suited for studying the effects of social interactions on well-being. In regard to healthy aging, the results presented in this dissertation highlight the significant potential of social interactions for promoting well-being and health in the daily lives of older adults, as well as the additional potential offered by digital social interactions.

Zusammenfassung

Die vorliegende Dissertation untersucht die Zusammenhänge zwischen sozialen Interaktionen in unterschiedlichen Modalitäten sowie Wohlbefinden und Gesundheit im Alltag älterer Erwachsener. Soziale Verbundenheit ist ein zentraler Faktor für Wohlbefinden und Gesundheit, doch Unterschiede in den Auswirkungen sozialer Interaktionen in verschiedenen Modalitäten auf das Wohlbefinden und die Gesundheit im hohen Erwachsenenalter sind bisher unzureichend erforscht. Ziel dieser Dissertation ist es daher, die Rolle verschiedener Interaktionsmodalitäten in dem Zusammenhang zwischen sozialer Interaktion und Wohlbefinden zu untersuchen. Ein besonderer Schwerpunkt liegt, vor dem Hintergrund der zunehmenden Digitalisierung, auf sozialen Interaktionen, die nicht in Präsenz stattfinden. Studie I untersuchte den Zusammenhang zwischen der wöchentlichen Häufigkeit sozialer Interaktionen in vier Modalitäten (persönlich, per Videoanruf, telefonisch und digital textbasiert) und positivem und negativem Affekt und Einsamkeit bei älteren Erwachsenen aus der Schweiz während der COVID-19 Pandemie. Studie II erweiterte diese Fragestellung, indem sie untersuchte, inwiefern die tägliche Häufigkeit sozialer Interaktionen in drei verschiedenen Modalitäten (persönlich, telefonisch und digital textbasiert) negative Auswirkungen von Gesundheitseinschränkungen auf das Wohlbefinden älterer Erwachsener aus der Schweiz abmildern kann. Studie III basierte auf Daten kanadischer älterer Erwachsener, die in Dyaden teilgenommen haben, und untersuchte, wie die Übereinstimmung in Partner*innenangaben zur gemeinsam verbrachten Zeit (persönlich und digital) mit dem täglichen Wohlbefinden während der COVID-19 Pandemie zusammenhing und inwiefern Unterschiede zwischen den Angaben der Partner*innen mit dem Wohlbefinden assoziiert sind. Die Ergebnisse aller drei Studien zeigten, dass eine höhere Frequenz sozialer Interaktionen mit höherem Wohlbefinden assoziiert war und dass persönliche Interaktionen am konsistentesten mit erhöhtem Wohlbefinden einhergingen. Ergebnisse aus Studie I und II deuteten jedoch darauf hin, dass auch soziale Interaktionen in weniger reichhaltigen Modalitäten positive Zusammenhänge mit dem Wohlbefinden aufweisen. Diese Effekte zeigten sich verstärkt, wenn persönliche Kontakte selten waren oder die Gesundheit als eingeschränkter empfunden wurde als sonst. Die Ergebnisse von Studie I legten nahe, dass digitale soziale Interaktionen fehlende persönliche Kontakte teilweise kompensieren konnten. Studie II zeigte, dass bei Personen mit höherer Frequenz digitaler Interaktionen die negativen Auswirkungen von Gesundheitsbeschwerden abgefedert werden konnten. Ergebnisse von Studie III deuteten darauf hin, dass die Übereinstimmung zwischen zwei Partner*innen in der

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Introduction

According to Baumeister and Leary (1995), feeling socially connected to others is a basic human need. They state that, in order to satisfy this need, two criteria are essential: having “frequent, affectively pleasant interactions with few other people” and that these interactions “take place in the context of a temporally stable and enduring framework of affective concern for each other’s welfare” (Baumeister & Leary, 1995, p. 497). Thus, social interactions are an essential part of human connections and social relationships. They build a foundation for a relationship, help to increase and maintain its quality, enable social support and thereby help to foster the feeling of connectedness. Further, socially interacting with others is an almost mundane part of everyday life: whether it is talking with a family member, a service person, a coworker, a roommate, a friend, an acquaintance, or stranger on the bus. Rowe and Kahn (1997) propose that active engagement in life is one of three major factors for successful aging, underlining the importance of social connectedness for the aging process. They thereby assign similar importance to social life as they do to maintaining physical and cognitive function, and to minimizing the risk of disease and disability. A review of their own model (Rowe & Kahn, 2015) emphasized the role of the individual’s immediate interpersonal environment for well-being, referencing other developmental psychology theories that focus on successfully adjusting to age-related changes and incorporating those changes into realistic goal setting in everyday life.

Baltes and Lang (1997) found that resource-rich older adults (meaning older adults who have high levels of resources both in social domains and cognitive domains) show fewer negative age-related changes in everyday activities and functioning than resource-poor older adults. Their results emphasize that maintaining high cognitive functioning alone does not constitute successful aging, but that social resources, such as perceived social support and a diverse social network, play an equally important role and complement the need for cognitive and physical functioning to ensure well-being in old age.

Older age is often associated with losses within social networks: either due to disease or death, the loss of social roles (e.g. due to retirement), or physical decline resulting in loss of autonomy and mobility (P. B. Baltes & M. M. Baltes, 1990). Demographic changes might also pose a threat to older adults experiencing social isolation with younger generations often moving further away from rural areas and into more urban areas and cities. Digitalization might provide a feasible and low-threshold opportunity to stay connected (Khosravi et al.,

2016), even when facing declining mobility, smaller network sizes, or family and friends living further away. Thus, socially interacting via different modalities, and not only in-person, could be a major resource for older adults to stay connected in late life (Ruiz-Figueroa et al., 2025). This might impact the development of social network sizes in older adulthood and could be a strong resource for well-being when age-related losses increase the risk of being socially isolated.

Nevertheless, the impact of social interactions, and especially digitally-mediated social interactions, on everyday life of older adults still remains understudied. Thus, this dissertation aims to add to the empirical landscape by examining possible beneficial effects of frequency of social interactions in different modalities on well-being in different contexts relevant to older adults' daily lives. Those contexts include unique and stressful external events such as the COVID-19 pandemic (Study I and III), as well as self-rated poor health and the number of health complaints (Study II). Study III also includes the partner perspective, allowing for the assessment of congruence between the individual and the partner's assessment of social time spent together.

This dissertation addresses several research questions: (1) How is the frequency of social interactions associated with daily well-being and loneliness in older adults' lives? (2) Can frequent social interactions not only improve well-being but also buffer adverse effects of poor health on well-being? (3) How do one's own and one's partner's perceptions of the time spent together affect well-being? The overall aim of this thesis is to understand the role that interaction modalities play in these associations. Thus, all studies distinguished between different interaction modalities. Study I assessed the weekly frequency of face-to-face interactions, video calls, telephone calls, and digital text-based communication. Study II assessed the daily frequency of face-to-face interactions, telephone calls, and digital text-based communication. Study III assessed daily time reports, indicating how much time participants spent with their study partner either face-to-face or digitally. Moreover, by combining different measures (frequency and estimated duration) and time frames (weekly and daily), this thesis seeks to offer a more nuanced view of everyday social interactions and to determine which methods best capture their relationship with well-being, loneliness, and health.

The following sections introduce the role that social relationships play in health and well-being, with a focus on how social networks change in older adulthood. This is meant to underline the necessity of studying older adults separately from lifespan samples and to

embed social interactions in a broader context. After that, the role of social interactions for daily well-being will be explored, with a focus on empirical evidence regarding the effects of different interaction modalities on well-being and the role that age plays in these associations. Different communication theories will be introduced that guided the formulation of the research questions for the studies presented in this dissertation. Lastly, a third part of this introduction will elaborate on studying well-being, health, and social interactions in daily life, why variation is assumed, and what kinds of timeframes the studies in this thesis used and why. Concluding these parts of the introduction, specific research questions that are addressed by this thesis will be presented.

Social Relationships Across the Lifespan

According to the Convoy Model of Social Relations (Antonucci et al., 2014; Kahn & Antonucci, 1980), people are surrounded by other people throughout their whole lives with whom their relationships vary in closeness, function, quality, and structure. In the model, these relationships are conceptualized as concentric layers surrounding the individual, representing different degrees of emotional closeness. People who are emotionally closer to the individual are assigned to the inner circle, while people with less emotional closeness to the individual are assigned to the outer circles. Across the lifespan, these convoys are stable in the sense that they are always there, but they undergo changes as relationships and life circumstances change. Thus, it is possible to switch from outer to inner circle and vice versa. Individual demands on the convoys are heavily influenced by person-specific factors such as an individual's age or gender, but also by situational characteristics such as phase of life, role demands, and societal norms. With its focus on the emotional closeness of relationships, the Convoy Model of Social Relations emphasizes the quality of relationships. The quality of relationships is undeniably an important factor when considering social relationships' impact on physical and psychological well-being and health (Fiorillo & Sabatini, 2011; Yang et al., 2016). However, Antonucci et al. (2014) state that without a certain quantity of these relationships, a high quality would not be possible to achieve and maintain.

Across the lifespan, people's social networks change: not only, as proposed in the Convoy Model, by exchanging people from one circle to another due to changing contextual factors, but also due to motivational shifts. Carstensen and colleagues proposed the Socioemotional Selectivity Theory (SST, Carstensen et al., 1999), which explains a declining social network size as people grow older through a change in goals initiated by limited time perspective (English & Carstensen, 2014). The theory suggests that when people perceive

their time as limited, for example in old age, they tend to prioritize short-term goals such as social connectedness and emotionally pleasant interactions, while placing less emphasis on long-term goals like networking or forming new relationships that require time to develop emotional closeness. This is based on the assumption that interactions with close others are more likely to be emotionally rewarding and less likely to be upsetting or draining. The theory has received substantial empirical support (English & Carstensen, 2014), also in diverse cultural settings: Fung et al. (2001) found support for the SST in large lifespan samples (age ranging from 18 to 94 years) from the African and European continents. Their data show that older adults have as many emotionally close social partners in their social network as younger adults, but that they report fewer peripheral contacts compared to younger groups. A longitudinal study with a diverse US-sample shows that over time, as people age, their social networks tend to become more restricted, which is inversely associated with self-rated health (Piedra & Iveniuk, 2025). Restricted social networks consist of few social connections and a high proportion of family ties within the network, indicating little diversity in social contacts, and high levels of loneliness. In contrast, richer social networks are characterized by higher marriage rates, more non-family social ties, and higher frequency of social interactions with diverse interaction partners. Over time, more people transition from enriched to restricted social networks, which increases the risk of experiencing loneliness and social isolation, in turn leading to decreases in health and well-being (Holt-Lunstad et al., 2010). The SST focuses mostly on future time perspective, which can be associated with older age but is not necessarily the same. However, Lang and Carstensen (2002) explored different perceptions of future time and goals in a large German lifespan sample. Findings reveal that older participants perceive future time as more limited than younger participants.

A meta-analysis by Wrzus et al. (2013) found that strong network connections with people like neighbors or coworkers were especially important during specific age ranges to support normative life changes (e.g., entering retirement or parenthood). Using social networks to cope with specific, normative changes and adjustments also fits well with the model of Selection, Optimization and Compensation (SOC Model; P. B. Baltes & M. M. Baltes, 1990). The model is based on the assumption that, across the lifespan, development is characterized by gains and losses, and that optimal development occurs when people cope positively with those changes in resources (physical, cognitive, and social). This happens (1) by selecting goals, contexts, and environments that are appropriate for the current stage of life; (2) by optimizing the abilities, strategies, and use of resources to fulfill those goals, and (3) by compensating for abilities or resources that were available before and are no longer

accessible (e.g., due to age-related losses). Optimization plays a larger role in younger age groups, as it is mostly associated with gains in ability, network size, and resources, whereas compensation plays a larger role as people age, since it is more strongly associated with adapting to changes in abilities and resources. These processes can guarantee relatively stable functioning in daily life and thereby contribute to stabilizing and enhancing well-being. Social relationships across the lifespan and in old age can be seen as important resources for older adults in setting suitable goals, optimizing quality of life by enhancing available social and emotional support, and thus also helping to compensate for age-related changes. An extension of the model, the Collective Model of Selective Optimization with Compensation (Hoppmann & Gerstorf, 2016), focuses even more on close intimate social relationships. The model suggests that especially very close others are a key resource for reevaluating goals and offering instrumental as well as emotional support.

In sum, advancing our understanding of how to effectively support older adults in maintaining diverse and meaningful social networks is essential, as social connectedness is fundamental to well-being and a sense of belonging (Baumeister & Leary, 1995).

Well-Being, Loneliness, and Health in Older Adulthood

Social network size and structure have been shown to be associated with health and well-being outcomes (Piedra & Iveniuk, 2025). At the current state of empirical evidence, the importance of social relationships for physical as well as psychological well-being and health is undeniable: A meta-analysis by Holt-Lunstad et al. (2010) suggests that having strong social relationships can reduce mortality risk by up to 50 % in older age, making social isolation a risk factor for health and mortality that is comparable to other well-established risk factors such as smoking. Having strong social relationships also implies having more social support, which has been identified as a protective factor against several physical and psychological health issues (Yang et al., 2016). The buffering hypothesis of social support (Cohen & Wills, 1985) suggests that social support can protect individuals from adverse effects of stressful events. Stress is defined as a situation that an individual evaluates as threatening and hard to cope with, exceeding their own resources to deal with the stressor (Lazarus, 1966). Social support can buffer stress outcomes in two ways: either by offering instrumental support and resources to handle the situation or by helping to reappraise the situation and thus regulate the stress response.

The aging process entails many stressful situations and circumstances such as declining health and limited autonomy, and psychological and physical distress occur

increasingly together, often in comorbidity (Hussenoeder et al., 2021). Successful coping with those changes and identifying protective factors may also be seen as compensating for age-related losses (SOC model; P. B. Baltes & M.M. Baltes, 1990), again underlining the importance of social resources for the aging process and in everyday life situations.

This dissertation defines well-being as a state characterized by high positive affect, low negative affect, and low levels of loneliness (Macdonald & Hülür, 2021). The subsequent section outlines how affective states and loneliness are conceptualized in this work, as well as in the three presented manuscripts. Throughout this dissertation, the term well-being will be used to reflect this operationalization.

Subjective well-being refers to the individual's evaluation and experience of their life (Diener, 1984). Well-being is often characterized as high when people report to be experiences high levels of positive affect and low levels of negative affect (Deci & Ryan, 2008). Oftentimes, high satisfaction with life, meaning evaluating one's current state of life as desirable or satisfactory (Diener, 1984), is also part of the concept of subjective well-being. However, life satisfaction requires a certain amount of cognitive evaluation, whereas affective states are more of a summarizing category of valenced states, moods, and emotions, i.e. happiness, anxiety, or sadness (Deci & Ryan, 2008; Gross, 1998). Thus, affective states are often used when examining well-being in a daily context to capture faster variability. Positive affect and negative affect are considered to be constructs on independent spectrums that can be high or low (Diener & Emmons, 1984; Diener & Iran-Nejad, 1986; Zevon & Tellegen, 1982), rather than endpoints of the same spectrum. Based on this theoretical framework and these empirical findings, positive affect and negative affect depict independent phenomena and provide unique information on the individuals' emotional state.

Even though older adulthood is characterized by losses (e.g., in health, autonomy, and personal relationships; P. B. Baltes & M. M. Baltes, 1990), research claimed for many years that the objective and subjective trajectory of quality of life did not align, since health complaints increase with age but well-being remains stable or even increases in older adulthood (Wettstein et al., 2016). The well-being paradox described that, on average, older adults do not report lower well-being than other age groups. However, this paradox is only somewhat supported when also including old-old participants (80+ years old): Subjective well-being seems to be stable up until very old age (despite decreases in other areas such as health), but towards end-of-life, subjective well-being does decrease (Hansen & Slagsvold, 2012; see also: Hartung et al., 2022). Changes in different domains of well-being, such as

positive and negative affect and life satisfaction, differ in onset and in longitudinal and cross-sectional settings, but seem to remain stable well into old age (Hansen & Slagsvold, 2012). Hansen and Blekesaune (2022) propose that stable and even increasing reports of well-being in middle and old age can be seen as successful adaptation to age-related changes, but that adaptive behaviors and coping can only go thus far and cannot prevent decrease in subjective well-being when health-related and social losses become too pronounced and constraints intensify. Since personal losses and health decline become more prevalent in old age, studying day-to-day influences of age-related factors on well-being is important to understand how the onset of decreasing well-being can be delayed and what factors are especially beneficial on a daily basis. Research on health sensitivity shows that daily variation in health is related to daily variation in well-being. Health sensitivity describes how susceptible an individual's well-being is to occasion- and day-specific variability in physical health (Schöllgen et al., 2016). Studies show that people with more functional limitations report less well-being and that these effects can be found on a between-person and a within-person level (Schöllgen et al., 2016). Nevertheless, older adults' well-being seems to be less susceptible to daily variability in health functions than younger age groups' well-being, which may indicate a certain amount of habituation with increasing age (Potter et al., 2022; Schöllgen et al., 2016) or hint at different emotion regulation or coping mechanisms to keep well-being high (see also P. B. Baltes & M. M. Baltes, 1990; Blanchard-Fields et al., 2004). In sum, these results again underline the necessity to study older adults and their daily variability in well-being separately from other age groups as underlying mechanisms to regulate well-being and factors effecting well-being seem to differ across age groups.

Loneliness is often defined as a subjective deficiency in an individual's social relationship network: The individual either perceives a deficiency in the quantity of social interactions or a deficiency in the quality of relationships, leaving the unpleasant feeling of an unmet desire or a mismatch between reality and ideal (Perlman & Peplau, 1981). Other scholars (De Jong Gierveld & Van Tilburg, 2010) characterize loneliness by differentiating between experiencing close relationships as not as intimate as desired, defined as emotional loneliness, and evaluating one's social network as smaller than desired, defined as social loneliness. It is important to stress that loneliness is a subjective evaluation of the situation, and it is in some ways distinct from social isolation, which characterizes the actual state of minimal social connection (Hawkey & Cacioppo, 2010). The commonality among definitions of loneliness lies in the aspect that loneliness derives from the individual's perception of being isolated, alone, insufficiently supported, or not surrounded by enough or strong social

networks. Part of most definitions of loneliness are evaluations of (insufficient) social interactions (Ruiz-Figueroa et al., 2025).

Oftentimes, it is proposed that loneliness increases as people grow older and that older adults are especially vulnerable to being socially isolated, and in turn, feeling lonely (Seifert, 2023; Van Tilburg et al., 2021). Loneliness seems to be highest in young adulthood (around the age of 30 years) and again in the oldest old (80+ years old; Luhmann & Hawkey, 2016), possibly linked to higher prevalence of functional decline, lower income levels (due to retirement), and not being partnered. Research cannot back up the assumption that people today feel more lonely than a few decades ago (Suanet et al., 2024; Vasile & Aartsen, 2025); however, studies still show that the prevalence of feeling lonely in older adulthood is relatively high. A recent meta-analysis (Susanty et al., 2025) also shows that loneliness increases with age: of those aged 60 to 74 years old, 21% report feeling lonely, of those aged 75 to 84 years, 34% report feeling lonely and in the oldest age group (85 years and older), 42% report feeling lonely. Previous findings show that technology-mediated social interactions can mitigate, but not eliminate, the feeling of loneliness in older adults (Ruiz-Figueroa et al., 2025). Positive associations between digital social interactions and decreased loneliness might be especially strong for older adults compared to younger age groups (Seifert, 2025).

We decided to integrate loneliness into our conceptualization of well-being, since it has been shown that social interactions are related to daily variability in loneliness as well as affective states (e.g., Lin & Lachman, 2021; Ruiz-Figueroa et al., 2025; Skałacka & Pajestka, 2021). Moreover, some scales measuring negative affect include items such as feeling lonely or isolated (e.g., Watson et al., 1988) and we wanted to put more emphasis on this aspect of well-being.

The Role of Social Interactions for Well-Being, Loneliness, and Health

One way of keeping a certain social network size and maintain strong social relationships is by socially interacting with others (Piedra & Iveniuk, 2025). The positive association those social interactions have with well-being and health outcomes has been studied in various studies (Fiorillo & Sabatini, 2011; Teo et al., 2015). Frequency of social interactions has also been associated with several indicators of well-being such as mood, positive and negative affect, and life satisfaction (Antonucci et al., 2014; Fiorillo & Sabatini, 2011; Gaia et al., 2021; Kim & Fingerhant, 2022; Luo et al., 2022). For example, Fiorillo and Sabatini (2011) investigated the relationship between the quality of social relationships and the quantity of

having social interactions and health outcomes. They found that the quality of social relationships is the best predictor for reporting good self-reported health but that the quantity of social interactions was an important factor, too. Having an adequate quantity of social interactions is also important for psychological outcomes: Being satisfied with the amount of social interactions was found to be a protective factor for depressive symptoms (Hays et al., 1997). The quality of a social interaction is not only dependent on the closeness of the interaction partner. Huxhold et al. (2020) found that maintaining a high number of weak ties (e.g. with acquaintances) and having social interactions with them is associated with lower levels of depressive symptoms and higher levels of stable positive affect, indicating that peripheral social relationships should not be neglected and also play a role in the association between social interaction frequency and well-being. Nikitin et al. (2024) investigated whether social interactions become more meaningful in older age and found that when people interacted with a close other, they perceived the interaction as more meaningful. However, they also found that older participants, compared to younger participants (age range from 18 to 88 years), perceived more social interactions in total as meaningful. Engaging in meaningful social interactions has also been associated with experiencing lower levels of stress and loneliness and higher levels of well-being (Roshanaei et al., 2023). Thus, many different aspects of social interactions determine how they affect well-being and the picture might not be as clear cut as one might think. These results also indicate that social interactions and frequency of social interactions in daily lives affect age groups differently underlining again the necessity to study older adults separately. One major aspect of social interactions is how people interact with one another, whether they meet in-person or talk on the phone. Social interactions in different modalities are one focus point of this dissertation.

Theoretical Background on Interaction Modalities

One key theory of communication that focuses on differences of communication modalities is Media Richness Theory (Daft & Lengel, 1983). According to this theory, some interaction modalities are superior to other modalities in the “richness” of information they are able to convey. For example, face-to-face interactions offer the possibility to observe the interaction partner’s gestures, tone of voice, and facial expressions. Video-calls still offer information on facial expressions and voice and could therefore be considered closer in richness to face-to-face interactions than telephone calls or text-based conversations (Ishii et al., 2019).

Telephone calls also convey information about tone of voice and require immediate responses during a conversation, whereas digital text-based interactions, such as text-messages and

emails, simply rely on the written text and are not as time sensitive. Therefore, interaction partners can take their time responding to a message but also might miss out on intonation or other social cues.

One could assume that the richness of information conveyed during a social interaction affects the association between this social interaction and well-being. Previous studies concluding that face-to-face interactions might be uniquely positively associated with overall life satisfaction and relationship satisfaction support this assumption (Goodman-Deane et al., 2016; Lin & Lachman, 2021; Teo et al., 2015). Nevertheless, more recent perspectives also suggest that Media Richness Theory is too narrow to appropriately consider communication modalities in this hierarchy (Ishii et al., 2019). Given the fact that the theory was introduced in the 1980s, more modern interaction modalities were not considered in the model. For example, research to date finds mostly inconsistent results for the association of video-calls and well-being, even though, following the Media Richness Theory, they should be similarly positively associated with well-being as face-to-face interactions. Research on video-calls is relatively new, as an increase in usage has been observed especially during the COVID-19 pandemic. Many studies including video-calls examine workplace settings, and thus, it remains unclear whether these results can be transferred to other settings and other samples. Research suggests that interacting in a work place setting is a special case of socially interacting and thus associations with well-being outcomes are not necessarily similar to other settings: Within the work setting, social interactions might be associated with stress, work load, involuntary tasks and performance pressure (e.g., Hülshager & Schewe, 2011; Shanock et al., 2013). Moreover, much research on the topic of digital communication either uses lifespan or younger samples, and not explicitly older adult samples (e.g., Kafetsios et al., 2017), leaving a gap in understanding how digital communication affects different domains in later life.

Around the turn of the Millenium, concerns surfaced that feared that new, digital media would replace time that individuals spent with others face-to-face (e.g. Kraut et al., 1998), resulting in a decrease in well-being and health. However, empirical support for the Social Replacement Theory is limited and there is more empirical support for the idea that digital social interactions complement face-to-face social interactions rather than replace them (Hall & Liu, 2022; Kim & Fingerman, 2022).

However, even though most research suggests a unique role of face-to-face interactions for well-being, empirical evidence also shows that social interactions in other

modalities are beneficial. Chan (2015) proposes that multimodal connectedness, i.e., frequently interacting in more than one modality with others, is associated with higher levels of well-being. These associations were not found in younger age groups (18-35 years), but only in middle-aged (35-55 years) and older adults (55-70+ years), suggesting that incorporating different modalities in daily social interactions additionally to face-to-face interactions may be especially beneficial for older adult's well-being.

Media Multiplexity Theory (Haythornthwaite, 2001) claims that any medium can facilitate strong interpersonal bonds and that the closeness to the interaction partner influences how frequently a modality is used to communicate in a certain relationship. Haythornthwaite (2001) further argues that preexisting strong ties, e.g., with close family members, benefit from integrating digitally mediated social interactions in those relationships. Thus, relationship closeness influences the frequency in which different forms of media are used to stay in touch, the relationship stays close regardless of the used medium, and over time, the frequency of using different media to socially interact also influences relationship closeness.

The Role of Social Interaction Modality for Well-Being

Research suggests that the modality in which people interact with one another influences the association of social interactions and well-being outcomes. In general, the idea is that face-to-face interactions are most strongly related to positive well-being outcomes compared to other modalities such as phone calls, text-messages, or video-calls (Sacco & Ismail, 2014; Teo et al., 2015). Studies show that participants who reported more social interactions face-to-face reported greater needs satisfaction as well as more positive mood than participants who reported low social interaction frequency (Sacco & Ismail, 2014). Data from the Health and Retirement study suggests that individuals with most frequent face-to-face interactions at baseline show the lowest probability of depressive symptoms two years later (Teo et al., 2015) hinting at positive long-term effects of more frequent social interactions. Moreover, Sun et al. (2020) examined daily diary data from 110 participants from the United Kingdom (aged 18-71 years), assessing with whom and how they interacted across 30 days, and how interaction partners as well as modality were associated with their daily well-being reports. Results showed that social interactions in different modalities were differentially associated with well-being at the between- and the within-person level. Social interactions that did not take place in person and were technologically mediated (such as video-calls or emails/text-messages) predicted participants' well-being less consistently than face-to-face interactions. Face-to-face interactions were positively related to well-being both at the between- as well as the within-

person level, i.e., participants who reported a higher frequency of face-to-face interactions overall also reported higher well-being levels in general. Further, on days with more face-to-face interactions than usual, participant also reported higher well-being than usual. These patterns did not emerge for the other modalities. Text-based digital interactions were positively associated with well-being at the within-person level, whereas video-call interactions were associated only at the between-person level. Taken together, these findings suggest that social interactions exert differential effects on well-being depending on the modality through which they occur, which is in line with previous studies (e.g. M.-A. Lee et al., 2022; Skalačka & Pajestka, 2021) reporting similar patterns.

However, the inconsistency in findings for modalities that are not face-to-face also indicates that there is more to be explored. As social interactions have been shown to be important for psychological and physical well-being it is important to investigate further how social interactions should be carried out to be most beneficial. Moreover, these results also underline that one should not underestimate the potential benefits of social interactions that do not take place face-to-face. Even though face-to-face interactions were most consistently associated with well-being outcomes across studies (Kim & Fingerman, 2022; Lin & Lachman, 2021; Skalačka & Pajestka, 2021), most studies also found beneficial or partly beneficial effects of digitally mediated or telephone social interactions. With technology advancing and digitally mediated communication becoming more prevalent in daily life, it is important to investigate further what role these modalities play in fostering well-being and health, in order to draw conclusions and derive real-life implications from research findings. In sum, when researching the effects of social interactions, considering the modality in which social interactions are carried out is an important determinant.

The Impact of the COVID-19 Pandemic on Social Interactions

The outbreak of the COVID-19 pandemic in early 2020 made alternative, non-in-person ways of communication more necessary. Most governments introduced social distancing measures to prevent the spread of the virus, thereby limiting social interactions with various people and reducing social network sizes. The World Health Organization (WHO) recommended staying in regular touch with loved ones via alternative interaction modalities such as email, text-messages, telephone calls, or video-calls to prevent social isolation and maintain well-being (World Health Organization, 2020). Thus, the pandemic made it necessary for many people to increase their online social activities, which was especially important for older adults, who increased their use of digitally mediated communication modalities during the pandemic

(Tomaz et al., 2021; Wike et al., 2022). The outbreak of the pandemic resulted in increased levels of stress and social isolation among older adults (Tomaz et al., 2021; Van Tilburg et al., 2021), as they were a high-risk group for a severe course of the disease in case of infection. Older adults also showed a decline in overall well-being (Macdonald & Hülür, 2021). In a study by Tomaz et al. (2021), Scottish older adults reported that one coping mechanism to adjust to the pandemic and deal with increased feelings of loneliness and social isolation was to increase their online social contact, which was also reflected in increased screentime.

The Role of Age in Choosing Different Interaction Modalities

Even before the outbreak of the pandemic, communicating with people via different modalities on a daily basis had become a reality in a society shaped by digitalization and technological advances (Hunsaker & Hargittai, 2018; Wike et al., 2022). With those advances, social interactions now take place through various different modalities with increasing frequency, mainly in addition to face-to-face contacts (Hall & Liu, 2022). A high majority of adults in Western countries have access to the internet with percentages ranging from 92% of adults in Belgium and France to 96% of adults in the Netherlands (Pew Research Centre, 2024), with high percentages of those people also using the internet to stay connected with others, e.g., through social media, ranging from 51 % in Germany to 75 % of adults in Canada.

One major demographic factor influencing internet and social media use is age (S. Lee, 2024): As data from the European Social Survey show, the oldest old in Europe (85+ years old) are less likely to regularly use the internet compared to the old-old (aged 75 - 84 years) and the young-old (aged 65 - 74 years). Other demographics also play crucial roles in whether people start and continue to use the internet. Data suggest that men are more likely to use the internet than women in old age, that non-retired older adults are more likely to use the internet regularly than retired older adults, and that higher education is also associated with more regular internet use (Hunsaker & Hargittai, 2018; S. Lee, 2024). Heo et al. (2015) found in a large US sample that older adults who use the internet regularly have a reduced risk of social isolation and loneliness, and that they use the internet to stay connected with family and friends. In-depth interviews with older adults identified that staying connected to one's social network, especially to those who are harder to reach, was one of the main reasons for older adults to use social media sites such as Facebook (Jung et al., 2017). A review of older adults' internet use and online behavior concludes that the relationship between internet use and well-being and mental health is promising (Hunsaker & Hargittai, 2018): the reviewed studies

report associations between increased internet use in older adults and greater perceived social support, decreased levels of loneliness, better life satisfaction, better psychological well-being, and overall better mental health in comparison to older adults with lower internet use rates. However, much of the presented work relies on cross-sectional data. Thus, studying potentially positive associations of internet use or the use of digital communication tools among older adults in longitudinal settings could shed light on how the use of digital tools shapes well-being and social connectedness over time.

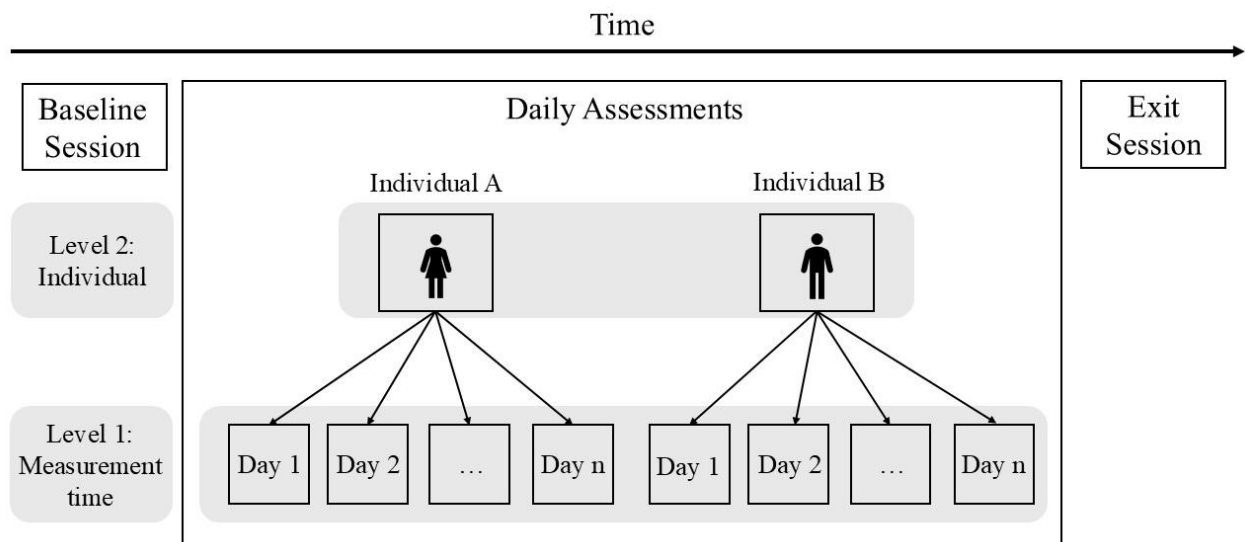
However, data from the Survey of Health, Aging and Retirement Europe (SHARE) also suggest that, once online, people do not necessarily stay online: König and Seifert (2020) show that changes in financial situation, health, and partner loss are associated with decreasing internet use. One can derive two major focus points from these data: First, it is important to investigate older adults as a distinct group when researching social interactions, digital connectedness, and well-being. Especially when researching the effects of digital communication modalities, research has either focused on younger age groups (e.g., Kafetsios et al., 2017) or lifespan samples (e.g., Lin & Lachman, 2021; Sun et al., 2020). Results from lifespan samples often propose differences in associations of social interactions, modalities and well-being between age groups (Chan, 2015; Sun et al., 2020; Tsang et al., 2022), underlining that not all age groups respond in the same way. Second, study results show different patterns of results for different interaction modalities at the between- and the within-person level (Kim & Fingerman, 2022; Lin & Lachman, 2024). This emphasizes the importance of investigating the association between social interactions in different modalities in daily life contexts. Well-being and health also vary on a daily basis (Buecker et al., 2024; Potter et al., 2022; Röcke & Brose, 2013), and daily assessments allow researchers to examine the influence of daily social interactions on those variables.

Methodological Considerations

The main focus of this thesis is to study the associations between social interactions and the variability of well-being and loneliness in a daily context. Thus, it is important to discuss measurements of these concepts in a daily setting. Micro-longitudinal research designs provide insights on both, intra- and inter-individual dynamics in an ecologically valid setting (Bolger et al., 2003; Bolger & Laurenceau, 2013). Intra-individual dynamics describe changes within an individual, e.g., one person's changes in affective states across multiple days or measurements. Inter-individual dynamics describe between-person differences, i.e. between individual A and individual B. By using this design, it is possible to investigate what type of

social determinants are associated with daily well-being and loneliness in general, capturing patterns of characteristics that are typically associated with certain outcomes (inter-individual associations). It is also possible to examine individual reactions to daily variations in these social determinants (intra-individual associations).

Figure 1. *Daily Diary Assessment Design.*



Daily Assessments of Well-Being, Loneliness, and Social interactions

Well-being varies on a daily basis, however, research suggests that in old age there is less daily variability in well-being (Röcke & Brose, 2013). This might be due to several reasons, one being that older adults are believed to be better at regulating their emotions (Birditt et al., 2005) and thus, neither negative nor positive events affect their average affective state that much. Research shows that older adults use different emotion regulation strategies than other age groups (Blanchard-Fields et al., 2004), revealing that older adults use passive emotion regulation strategies, such as intentionally redirecting thought and behaviors away from the situation or accepting the situation as is, to a greater degree than middle-ages adults. According to SST, older adults engage in fewer interactions that have a higher risk of being emotionally upsetting and thereby might filter out negative events before they happen (Carstensen et al., 1999) reducing threats to well-being in daily live. Observing those changes in daily life makes sense as they might help to interpret the bigger picture of maintaining an overall high well-being in older adulthood.

When studying affect in daily settings, according to Röcke and Brose (2013), one has to consider stable aspects of affective experiences, e.g., the general or the individual's average

emotional state, and conceptualize the variable aspects of emotional experiences as momentary deviations from the general state. By surveying the same participants multiple times across a predetermined timeframe, one can account for these participants' general state (e.g. the mean affective state they report repeatedly across this time frame) and for their momentary deviation from their own average. Similarly to affective states, loneliness also varies on a daily level (Buecker et al., 2024) and this variability is related to variability in social determinants such as social interactions (Awad et al., 2023).

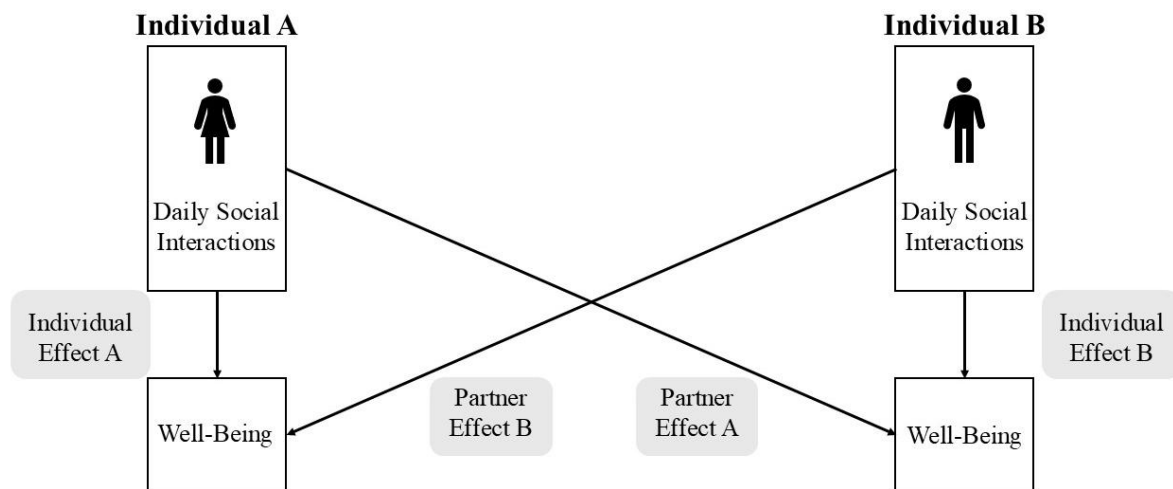
Affective states and loneliness are often measured using adjective lists in daily life. Participants are asked to indicate how much a certain adjective describes their affective state, e.g., at that moment, during that day or over the past week. A well-established and evaluated questionnaire for positive and negative affect is the Positive and Negative Affect Scale (PANAS; Breyer & Bluemke, 2016; Watson et al., 1988) and for loneliness the UCLA Loneliness Scale (P. B. Baltes & Mayer, 1998; Russell et al., 1984). Even though Brose et al. (2020) suggest that one should be careful when using measurements that were designed to observe between-person differences and not to account for within-person differences, these measurements show an overall satisfactory within-person reliability. An extensive assessment of the PANAS with older adults (Kercher, 1992) supports the usability of the PANAS and mood adjective lists in general to assess well-being in older adulthood and confirms that positive and negative affect are suitable measures for well-being in older adults' daily lives. All manuscripts presented in this dissertation either use these scales or modified versions of these scales to measure affect and loneliness in repeated-measures settings. Previous research shows that different measurement time scales can reveal specific associations better than others: Kraemer et al. (2025) conducted two studies, one measuring social interactions and affective states every hour for two days and one study measuring social interactions and affective states daily for 14 consecutive days. They found that, especially when examining lagged effects, for example, how affective states influence the seeking and initiating of social interactions, hourly measurements were more accurate and better suited to show variability and significant associations compared to daily measures. Roos et al. (2024) also found in a similar design to that of Kraemer and colleagues (2025), that within days, social desire predicted subsequent increased frequency of social interactions, but that this effect could not be found between days. Both studies underline that affective states and social interactions are associated with one another but that depending on the research focus, different time scales are differentially adequate.

There are different approaches to studying social interactions in a daily context. Many studies ask about the frequency of occurrences of social interactions, one example being “How often did you talk to someone today in-person?” (e.g., Lin & Lachman, 2021), or ask participants to log an event as soon as it happens (event sampling) and then calculate a daily sum score of the reported events (e.g., Macdonald et al., 2021). This approach was used in Studies I and II. Another possibility would be to ask for the duration of a social interaction (Sun et al., 2020) as we have done in Study III presented in this dissertation.

Dyadic Analysis of Longitudinal Data

As established earlier in this introduction, social interactions have been shown to have positive associations with numerous domains of well-being in the individual, such as improved mood, life satisfaction, and positive affective states (Gaia et al., 2021; Kim & Fingerman, 2022; Skalacka & Pajestka, 2021) that can be observed on a daily basis. The studies presented in this thesis all use daily diary data or experience sampling data that can be summarized under the umbrella term of intensive longitudinal data (Bolger & Laurenceau, 2013). Those designs allow researchers to investigate changes and variability within individuals in their natural setting due to variability in their environment. The presented studies all focus on the social environment, examining the frequency and duration of social interactions and their associations with the individual’s well-being and loneliness. Since social interactions occur between two or more individuals, they offer the opportunity to take not only the individual’s but also the partner’s perspectives into account. Collecting data from both interaction partners about the same events allows researchers to incorporate both viewpoints into the analysis. Hence, it is possible to investigate effects of specific determinants on both members of the dyad individually while still accounting for the statistical dependence of the partners (Hülür & Weber, 2019). Considering the role of the interaction partners, one should differentiate between distinguishable (e.g. one part of the dyad is the parent, the other part is the child) and indistinguishable dyads (roommates or close friends; both individuals have the same social role; Bolger & Laurenceau, 2013). In multi-level modeling, the analysis of dyadic data requires clustering individuals within dyads (Hülür & Weber, 2019). This approach adds an additional hierarchical level to the model compared to individual-level analyses, as time points are nested within individuals, and individuals are further nested within dyads.

Figure 2. *Dyadic Data Analysis Design.*



The Present Dissertation

This dissertation investigates the role of social interactions in older adults' daily well-being and loneliness with a special focus on the effects of different interaction modalities. To do so, the manuscripts in this dissertation differentiate between information-rich interaction modalities (face-to-face interactions) and less rich modalities (i.e. telephone calls or digitally mediated modalities). Earlier studies are relatively homogeneous in their finding that social interactions are beneficial for several daily life factors such as well-being, health and loneliness (e.g., Fiorillo & Sabatini, 2011; Kim & Fingerman, 2022; Skałacka & Pajestka, 2021). With digitalization advancing and technology-mediated communication tools becoming increasingly important in older adults' everyday lives (König et al., 2018; Pew Research Centre, 2024), it is important to investigate how the interaction modality affects the association between social interactions and well-being. Thus, more in-depth research is needed to focus on potentially differential effects of social interactions across modalities.

This dissertation consists of three separate manuscripts that are either published in scientific peer-reviewed journals or submitted for publication.

Study I uses data from 98 older adults that were collected weekly during the COVID-19 pandemic over the course of 64 weeks between April 2020 and June 2021 in Switzerland. The sample had a mean age of 72 years ($SD_{age} = 5$; $range_{age} = 65$ to 94 years) and 36% identified as women. Participants in Study I were a subsample of participants from Study II, who were contacted again after the outbreak of the COVID-19 pandemic. This study examines how the frequency of social interactions in four different modalities, i.e. face-to-

face, video-calls, telephone calls, and text-based digital, is associated with well-being in older adults and whether the effects of less rich interaction modalities, i.e., video-call, telephone calls, digital text-based, on well-being differ from the effects of face-to-face interactions.

Study II uses data from 118 Swiss older adults that was collected daily for 21 consecutive days in 2019. The sample's mean age was 72 years ($SD_{\text{age}} = 5.05$; $\text{range}_{\text{age}} = 65$ to 94 years) and 40% of the sample identified as women. Participants reported the frequency of their social interactions in three modalities (face-to-face, telephone calls, digital text-based interactions) and their daily well-being and loneliness, in addition to subjectively assessing their daily health. The study investigates how poor self-reported health affects daily well-being and whether social interactions in different modalities can serve as a buffer against in this adverse association.

Study III uses data from 274 older adults that are part of 137 dyads, respectively. The mean age in this sample was 66 years ($SD_{\text{age}} = 11.05$; $\text{range}_{\text{age}}: 18 - 87$ years) and 70% identified as women. Participants were recruited in British Columbia, Canada, and were asked to sign up to the study with a close other of their choice. Of all dyads, 58% were spouses, and 33% were living together. The data was collected between 2020 and 2021 on 10 consecutive days during the COVID-19 pandemic. Participants were asked to indicate how much waking time they spent with their study partner during the day both in-person and digitally. They further provided daily reports of well-being. The study investigates the question how the congruence in reports of time spent with one's study partner in comparison to the partners' reports affects well-being and whether the direction of discrepancy (over-estimating the time) is associated with elevated well-being.

In sum, the manuscripts of this dissertation add to the scientific literature by examining the association between social interactions and older adults' well-being in different time frames (daily and weekly), accounting for different situational contexts (pandemic, daily health variability, close social relationships), and by measuring social interactions in distinct ways (frequency of occurrence and estimated duration in minutes).

In the following, the three studies that were conducted as part of this dissertation will be presented. These sections will be followed by a general discussion and a synopsis of the results presented in the study manuscripts. The overall aim is to answer the proposed research questions that guided this dissertation. In summary, the research questions that this dissertation addresses are:

- (1) How is the frequency of social interactions associated with daily well-being and loneliness in older adults' lives?
- (2) Can frequent social interactions not only improve well-being but also buffer the adverse effects of poor health on well-being?
- (3) How do one's own and one's partner's perceptions of the time spent together affect well-being?

All research questions are further examined with special emphasis on potential differences across interaction modalities, since one of the main aims of this dissertation is to study the role of social interaction modalities in older adults' well-being and health.

Table 1. *Overview of Dissertation Manuscripts and Their Key Features.*

	Participants	Modalities	Time Frame	Social Interactions	Outcome Measurements
Study I	98 individuals ($M_{age} = 72$ years; 38% identified as women)	Face-to-face, video- calls, telephone calls, text-based digital	Weekly assessments 64 consecutive weeks	Frequency (sum score)	Positive affect, negative affect, loneliness
Study II	118 individuals ($M_{age} = 72$ years; 38% identified as women)	Face-to-face, telephone calls, text-based digital	Daily assessments 21 consecutive days	Frequency (sum score)	Positive affect, negative affect, loneliness
Study III	136 dyads / 272 individuals ($M_{age} = 66$ years; 70% identified as women)	Face-to-face, digital	Daily assessments 10 consecutive days	Duration (time spent with study partner in minutes)	Positive affect, negative affect, loneliness

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Manuscript I

The data for this manuscript were drawn from the KiA – Kommunikation im Alter COVID-19 study, which was developed and conceptualized by Professor Dr. Gizem Hülür and Dr. Birthe Macdonald at the University of Zürich. It is a continuation of the KiA – Kommunikation im Alter study, which was carried out in 2019. Participants who took part in the 2019 study were contacted again after the outbreak of the COVID-19 pandemic and asked whether they were willing to participate in another, similar study. Data were collected weekly between April 2020 and June 2021 from 98 participants.

The concept of the research question and data analysis was developed by Professor Dr. Gizem Hülür and myself. The literature search and manuscript preparation were conducted by me. Data analyses were performed by me with support from Professor Dr. Gizem Hülür. The first draft of the manuscript was written by me and reviewed by Professor Dr. Gizem Hülür and Dr. Birthe Macdonald. The manuscript was published in April 2024 in the journal *Psychology and Aging*.

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Study I: The Role of Social Interaction Modality for Well-Being in Older Adults

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Dataset and Analysis Code can be accessed at

https://osf.io/7atf3/?view_only=8644dc8c0238475397a4b75182274904 Conflicts of Interest:

Conflict of interest: The authors have no conflicts of interest to report.

Summary

It is well established that more frequent social interaction is associated with higher well-being across the lifespan. The present study examines the role of frequency of interactions via different modalities on older adults' weekly well-being during the COVID-19 pandemic, where people had to adapt their communication behavior and reduce in-person contact due to precautionary measures. We use data from 98 participants (age: $M=71$, $SD=5$), who documented their weekly frequency of communication via four interaction modalities as well as their loneliness, positive affect, and negative affect over up to 64 weeks. Results show that participants with overall higher frequency of face-to-face, telephone, and text-based interaction than others report higher levels of positive affect and lower levels of negative affect and loneliness than others. Participants report higher levels of well-being during weeks when they report more frequent face-to-face, telephone, and text-based interaction than their individual average. Unexpectedly, participants report higher levels of negative affect during weeks with more video-call interaction. Some effects of social interaction frequency on affect and loneliness are higher for face-to-face interactions vs. other modalities. In addition, interaction effects at within-person level indicate that the effects of weekly telephone and text-based interaction frequency on loneliness are stronger in weeks with relatively few face to-face interactions. Taken together, our findings suggest that social interactions via different modalities contribute to well-being, but that face-to-face interactions have the biggest effect. In addition, there is some evidence that telephone and text-based interaction may play a compensatory role.

Key words: social interaction, micro longitudinal, COVID-19 pandemic, well-being, older adults

Public Significance Statement

This study shows that, even though personal face-to-face interactions have the strongest positive effect on well-being and loneliness, social interactions in other modalities, such as telephone calls, emails, and text messages are also related to higher well-being and lower loneliness. Also, some evidence suggests that text-based digital and telephone communication may compensate for less frequent face-to-face social interactions. Unexpectedly, video-calls are not associated with well-being.

Theoretical Background

Connecting with other people is a fundamental human need. It is well documented that the frequency of social interactions is associated with several indicators of well-being, including life satisfaction, positive and negative affect and mood (Antonucci et al., 2014; Fiorillo & Sabatini, 2011; Kim & Fingerman, 2022; Luo et al., 2022). Social relationships continue to be of importance for well-being in older age (Heo et al., 2015; Luo et al., 2022). Although older adults use the internet at lower rates than other age groups (Scherpenzeel et al., 2020), research has shown that older adults increasingly use technology-mediated communication to stay in touch with family and friends (Antonucci et al., 2017). Since the outbreak of the COVID-19 pandemic, governmental restrictions to slow down the spread of the virus made it even more necessary for people to adjust their communication behaviors toward more digital and diverse forms. Therefore, it is of interest which modes of communication, in addition to face-to-face communication, could prevent loneliness in older adults and promote well-being. In the present experience-sampling study, we examine the role of communication frequency via different modalities (face-to-face, telephone, digital text based, video calls) during 64 weeks of the COVID-19 pandemic in longitudinal survey data on a weekly basis from 98 older adults in Switzerland (65+ years old).

Communication and Well-Being: The Role of Modality

Several theoretical perspectives in psychology emphasize the importance of social connection. According to Baumeister and Leary (1995), the need to belong is a fundamental human need that is of similar importance as daily necessities. This means that humans seek for pleasant interactions with others to build and maintain meaningful relationships and to satisfy their need of belonging. The need to belong may also serve as a motivational force for people to seek social interactions: When people are feeling lonely, their need to belong is dissatisfied and therefore, they approach others for interaction (Hall et al., 2022). According to the media richness theory (Ishii et al. 2019; Lengel 1983; Daft and Lengel 1983), people communicate via different interaction modalities and some of these modalities are superior to others in the “richness” of information they are able to convey. Face-to-face interactions are considered especially rich in information as they include information from, for example, body language and facial expression (Daft & Lengel, 1983). From the perspective of the media multiplexity theory (Haythornthwaite, 2005), every medium can facilitate strong interpersonal relationships and the closeness of a relationship influences how frequently people use different interaction modalities. In addition, the frequency of used modalities and interactions

also shapes relationship closeness. In line with the media multiplexity theory, Chan (2015) found that multi-modal connectedness, i.e., being frequently connected via more than one interaction modality, is associated with higher levels of well-being. These findings suggest that including digital forms of communication in preexisting relationships is beneficial for well-being. Many studies conclude that face-to-face interaction plays a uniquely important role in facilitating well-being amongst all age cohorts (Facco & Ismail, 2014; Goodman Deane et al., 2016; Lin & Lachman, 2021; Teo et al., 2015). In a diary study with an adult lifespan sample (22 - 94 years old) by Lin and Lachman (2021), days on which participants reported more face-to-face interactions were associated with more positive affect. Days with more telephone interactions were associated with less negative affect and days with more text based interactions were related to more negative affect and stress exposure. The frequency of face-to-face interactions also has positive long-term effects: Based on longitudinal data from the Health and Retirement Study, Teo et al. (2015) found that individuals with most frequent face-to-face interactions had the lowest probability of depressive symptoms two years later.

Digital Communication in Old Age

With technological advances, digital communication is becoming part of everyone's daily life. While younger people are more active with digital technologies, older people use the internet at an increasing rate in many industrialized countries. However, it remains unclear whether results from younger samples can be generalized to older adults. Tsang et al. (2022) studied effects of face-to-face and virtual social interactions on loneliness and well-being in younger ($M_{\text{age}} = 22.87$ years) and older adults ($M_{\text{age}} = 64.53$ years) during the first months of the COVID-19 pandemic. While face-to-face social interactions were related to lower levels of daily loneliness for both younger and older adults, some of the results differed by age group: For example, older adults who engaged in more virtual social interactions than others reported more positive affective experiences than others, while the same association was not found in younger adults. Chan (2015) also found that multi-modal connectedness, i.e., using several forms of interaction modalities for interacting with relationship partners, was associated with well-being in middle-aged and older age groups (aged 35-55 and 55-70+) but not for younger adults (18-35 years). This further underlines the necessity to study digital interaction modalities in different age groups.

Digital Communication During the COVID-19 Pandemic

After the outbreak of the COVID-19 pandemic in early 2020, social distancing measures were introduced to prevent the spreading of the virus. The World Health Organization

recommended keeping a physical distance to people who did not belong to one's own household, and most governments implemented these recommendations. The WHO also recommended keeping regular contact with others, especially loved ones, by phone, video calls, text messages or emails (World Health Organization, 2020). During the pandemic, older adults from the United States reported that the internet was an essential tool for them to keep in touch with friends and family (Pew Research Centre, 2021). The majority of participants in a study of Scottish older adults (60+ years old) reported using web conferencing and technology-based methods to stay in contact with loved ones during the lockdown (Tomaz et al., 2021). Even though the internet and digital communication use has especially increased among older adults during the COVID-19 pandemic, a trend in this direction was already foreseeable earlier (Wike et al., 2022) indicating that research on this topic will be relevant beyond the pandemic.

Governmental responses in Switzerland to the COVID-19 pandemic were similar to those in neighboring European countries like Germany, the Netherlands, Belgium, and the UK (Hale et al., 2021). Beginning in March 2020 and depending on the number of hospitalizations, the government installed stay-at-home recommendations, school and workplace closings as well as cancellations or reductions of public events and gatherings. During the summer, restrictions by government were usually loosened, while in winter, they were stricter (Swiss Federal Office of Health, 2023)¹. More information on strictness of restrictions can be found in our supplemental materials in Section 2.

In general, social distancing measures made older adults experience a decline in well-being and increase in loneliness. In a study with Swiss older adults, participants showed an increase in negative affect and loneliness and decline in positive affect during the COVID-19 pandemic with 2019 (Macdonald & Hülür, 2021). Data collected during the COVID-19 pandemic from older adults aged 62 years or older from over 27 countries indicated that social isolation predicts poor mental health in older adults (Kim & Jung, 2021).

However, research has shown that the frequency and modality of communication can have a positive impact on people's well-being. For example, the use of social media and digital ways of communication during and after the outbreak of COVID-19 was associated with life satisfaction in old age (Gaia et al., 2021). Older adults who frequently used the internet had a reduced risk of social isolation and of feelings of loneliness (Tomaz et al., 2021). Sun et al. (2020) conducted a 30-day diary study with an adult lifespan sample (from ages 18 to 71 years) in the United Kingdom during the first period of COVID-19 lockdown

measures in 2020. Participants completed daily questionnaires about which interaction modality they used to interact with others, with whom they interacted, and for how long while also indicating their daily well-being. Results showed that face-to-face interaction is most strongly related to daily well-being at the between- and within-person levels, while similar associations were not found for the frequency of use of telephone. At the between-person level, participants with higher frequency of video-calls reported higher levels of well-being.

Digital Communication and Well-Being

According to media richness theory (Ishii et al., 2019), video-calls can be considered closer to face-to-face interaction in terms of richness of information compared with telephone and digital text-based communication. Therefore, it is possible that communicating via video calls also contributes positively to well-being and negatively to loneliness. Nevertheless, research to date has shown inconsistent results. As noted above, Sun et al. (2020) found that participants between ages 18 and 71 who reported more frequent video-call interaction than other participants also reported significantly higher well-being. To the contrary, using cross sectional data from 60+ year old participants of SHARE (Scherpenzeel et al., 2020), Skalacka and Pajestka (2021) found higher frequency of video-call interactions with relatives to be associated with more negative mental health indicators, including higher levels of anxiety, depression symptoms, and loneliness. It is unclear whether these discrepancies in findings are based on methodological differences (e.g., experience sampling vs. survey study) or age ranges of the samples.

So far, few studies examined whether and to what extent digital interaction modalities can compensate for lack of face-to-face contact. For example, results from a study with 310 community-dwelling older adults ($M_{\text{age}} = 73.96$) by Kim and Fingerma (2022) suggest that social media use can complement benefits from daily social encounters by compensating for decreasing network sizes in older age. In their diary study, more daily social media use was associated with more positive mood for participants who had a smaller social network, whereas there were no significant positive effects for participants with larger social networks. A study with Korean older adults by Lee et al. (2021) examined associations of communication with depressive symptoms and showed that higher frequency of digital interaction modality use was more beneficial for those participants who had less frequent face-to-face contact than for those who had frequent face-to-face contact. Thus, evidence for compensating effects of digital interaction modalities for well-being exists, but it remains

unclear which specific interaction modalities play a compensatory role as digital communication was inconsistently defined in different studies.

The Present Study

The present study aims at examining how communication via different modalities is related to the well-being of older adults during the COVID-19 pandemic. Current evidence is limited regarding how the use of digital communication technologies contributes to well-being in older adults and whether it can compensate for the lack of face-to-face contact. The present study adds to prior research by examining participants' communication behavior and well-being over a time span of 64 weeks (March 2020 to July 2021) and considering not only between-person differences but also fluctuations in communication and well-being at the within-person level over weeks. Further, it differentiates not only between face-to-face communication and digital communication, but considers video-call, telephone, and text based digital interactions as separate interaction modalities. As outcomes, we focused on three aspects of well-being including positive affect, negative affect, and loneliness in order to achieve a rich operationalization of psychological well-being. These aspects were chosen as they vary in daily life and are associated with the frequency of social interactions (e.g. Hall et al., 2022; Chan, 2005; Lin & Lachman, 2021). We controlled for variables that can be expected to be related to individual differences in both well-being and social interaction frequency, including age, gender, health status, marital status, income, computer proficiency, and subjective technology adaptivity (e.g. Antonucci et al., 2017; Gaia et al., 2021).

To assess possible compensatory effects of digital interaction modalities, we examined interaction effects of face-to-face interactions with the other interaction modalities. Compensation would indicate that decreases in well-being associated with less frequent face to-face interaction would be reduced when other interaction modalities are more frequently used.

A previous study based on the same sample, but data collected prior to the COVID-19 pandemic (Macdonald et al., 2021), examined the role of social interaction frequency for older adults' well-being with a focus on three interaction modalities daily (face-to-face, telephone, digital communication) over the course of 21 days. Results suggested that face-to-face interaction is uniquely and more consistently related to older adults' daily well-being than interaction via telephone or digital communication tools. However, the study was unable to examine video-calls as a separate category because this modality was rarely used over the observation period. With this study, we are able to observe the associations of video-call

frequency with well-being and examine all four interaction modalities over a longer period of time. In order to collect data over a longer period (64 weeks), we preferred weekly assessments of interaction frequency and well-being to make the participation in our study more convenient.

Research Questions and Hypotheses

Based on media richness theory and accumulating evidence from previous studies (Goodman-Deane et al., 2016; Ishii et al., 2019; Lin & Lachman, 2021; Teo et al., 2015), we expect participants with a higher frequency of face-to-face interactions over the study period to experience higher levels of well-being (more positive affect, and less negative affect and less loneliness) than participants with less frequent face-to-face interactions (between-person level). We expect similar results for the frequency video-calls because according to media richness theory, video-calls are closer to face-to-face interaction in the richness of information they convey compared with telephone and text-based digital interactions (Ishii et al., 2019). Based on earlier results from the same sample, we do not expect the frequencies of telephone calls and digital text-based interaction to be related to well-being. In line with results from Macdonald et al. (2021), we further expect that people experience higher levels of well-being than usual during weeks when they engage in face-to-face interaction than they typically do. We expect the frequency of video-call interactions to show similar associations with well-being, however, we do not expect similar effects for social interaction frequency via telephone and/or text-based digital communication. Macdonald et al. (2021) did not find compensatory effects of telephone or text-based communication for the lack of face-to-face interactions on daily well-being, whereas Lee et al. (2020) found that digital technology use buffered the effects of infrequent face-to-face interactions on depressive symptoms in older Korean adults. During the COVID-19 pandemic, it was necessary to reduce face-to-face interactions (WHO World Health Organisation), which made the question of compensatory benefits of digital interaction modalities for well-being even more important. Due to these situational changes in the environment during the COVID-19 pandemic, we expect to find evidence for compensation as indicated by interaction effects of face-to-face social interactions with video call, telephone, and text-based digital interactions. We expect that when the other interaction modalities are more frequently used, the negative effects of less frequent face-to-face interactions on well-being are less intense.

Method

Detailed descriptions of participants, procedures, and measures can be found in earlier publications (Macdonald & Hülür, 2020). Select details relevant to the present study are given below.

Transparency and Openness.

The study procedures were reviewed and approved by the Ethics Committee of the Faculty of Arts and Social Sciences at the University of Zurich (Nr. 19.2.17) under the title “Communication and Interaction in Old Age”. The hypotheses and analytic plan were not pre-registered. The dataset and analysis code can be accessed online. The link can be found in the author note.

Participants and Procedure.

We use data from 98 older adults ($M_{\text{age}} = 72$; $SD_{\text{age}} = 5$; $\text{range}_{\text{age}} = 65$ to 94 years; 37 identified as female, 61 identified as male) from German-speaking regions of Switzerland who participated in a 3-week experience sampling study in 2019 (Macdonald & Hülür, 2020) and were contacted again in March 2020 by e-mail to participate in a follow-up study during the COVID-19 pandemic from March 2020 to July 2021. Participants who did not take part in the follow-up survey were excluded from analysis. Initially, participants were recruited via local and national newspapers, and through a database of participants hosted at the University of Zurich in Switzerland. Inclusion criteria were being fluent in German, being at least 65 years old or older, sufficient hearing and vision, and the use of digital devices for communication. Participation in the follow-up survey was incentivized with the chance to win one of five book vouchers of 50 Swiss Francs every four weeks. Alternatively, participants could choose to donate the same amount to a charity of their choice. We used all available weekly longitudinal observations across up to 64 weeks per participant. Data from two participants were excluded due to missing data on control variables. The vast majority of participants was retired (92 out of 98). 84 of the 98 participants were born in Switzerland (86% of the sample). By the end of our data collection in July 2021, 71 participants answered a final questionnaire that asked about their vaccination status. Of those 71 participants, 91% were vaccinated at least once by that time. For most participants, vaccination typically took place in the months January to June in 2021. All participants received the initial invitation for the study at the same time and invitations to complete the weekly questionnaires were sent to all participants simultaneously on a weekly basis. Participants could complete the questionnaire within a week and received no additional reminders. If participants did not

answer a questionnaire, they have missing data in that week but were able to continue with the study in the following week. On average, participants completed 46 out of 64 possible questionnaires ($SD = 20.56$).

Measures

Descriptive statistics and correlations of study variables are reported in Table 1.

Table 1. Descriptive statistics and intercorrelations of study variables

Variables	<i>M or %</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Age	71.43	4.90														
2. Gender (% men)	61%		.081													
3. Marital status (% married)	56%		-.142	.414												
4. Living alone (%)	40%		.172	-.442	-.793											
5. Health Conditions	2.28	1.79	.270	-.222	-.232	.190										
6. Income	3.68	1.46	-.122	.250	.472	-.497	-.159									
7. Computer Proficiency	133.81	20.52	-.163	.181	.209	-.200	-.127	.308								
8. Subjective Technology Adaptivity	43.17	10.78	.072	.117	.093	-.130	.084	.217	.495							
9. Weekly Face-to-Face Interactions	2.80	1.01	.095	-.212	.275	-.266	-.266	.346	.355	.210						
10. Weekly Video-Call Interactions	0.54	0.70	.025	.165	.195	-.299	-.025	.357	.182	.253	.084					
11. Weekly Telephone Interactions	2.56	0.91	.192	-.039	-.133	-.001	.036	-.098	.004	-.042	.235	.090				
12. Weekly Text-Based Digital Interactions	3.09	0.99	-.211	-.190	-.060	-.045	-.052	.122	.290	.174	.331	.021	.438			
13. Positive affect	71.98	16.89	-.173	-.037	.082	-.070	-.297	.138	.097	-.126	.263	.091	.200	.320		
14. Negative affect	27.15	19.63	.095	-.023	-.030	-.022	.300	-.011	-.128	.115	-.298	.057	-.208	-.309	-.810	
15. Loneliness	1.97	0.55	.300	-.214	-.216	.266	.347	-.190	-.289	-.061	-.491	-.122	-.256	-.516	-.565	.599

Notes: $n = 98$; 4,512 observations. Correlation coefficients represent Pearson's r . Bolded values indicate $p < .05$. Abbreviations: M = mean. SD = standard deviation.

Outcomes. Well-being was measured using selected items from the German version (Röcke & Grünh, 2003) of the Positive and Negative Affect Schedule Expanded Form (Clark & Watson, 1994). Participants answered the question: “In the following you will read a series of words that describe different feelings and sensations. Read each word carefully and use the answer scale to indicate how often you have felt this feeling / emotion during last week.” for four items measuring positive affect (strong, determined, calm, happy) and for four items for measuring negative affect (distressed, upset, irritable, unhappy) using a slider scale from 0 “not at all” to 100 “extremely”. The reliability of positive affect assessed with these four items was good at the within-person level ($\omega = .661$) and excellent at the between-person level ($\omega = .941$). The reliability of negative affect was also good ($\omega = .754$) at the within-person level and excellent $\omega = .964$) at the between-person level. Loneliness was assessed with eight items from the UCLA Loneliness Scale (Baltes & Mayer, 1999; Russell et al., 1984) on a five-point scale (1 = disagree strongly, 5 = agree strongly) ($M = 1.97$, $SD = 0.62$). The reliability of loneliness was low at the within-person level ($\omega = .475$) and excellent ($\omega = .931$) at the between-person level. Implications of the low within-person reliability of the loneliness scale will be discussed. We calculated the intra-class-correlations (ICC) for time-varying variables using the lme4 package (Bates et al. 2015) in R indicating the proportion of between-person variance in relation to the total variance. The ICC was highest for loneliness (ICC = .82), followed by positive affect (ICC = .69) and negative affect (ICC = .67).

Predictors. Weekly interaction frequency per modality was indicated by the frequency of face-to-face interactions ($M = 2.80$, $SD = 1.01$), video-call interactions ($M = 0.54$, $SD = 0.70$), telephone interactions ($M = 2.56$, $SD = 0.91$), and digital text-based interactions ($M = 3.09$, $SD = 0.99$) during the previous week on a five-point scale (4= several times daily, 3 = daily, 2 = several times a week, 1 = once a week, 0 = not at all). The frequency variables were separated into time-invariant and time-varying components (Bolger & Laurenceau, 2013). The “trait”-like between-person component was calculated as the average across an individual’s time series, indicating the average frequency of communication via a given modality over the study period of up to 64 weeks. The within-person components, as “state” variables, indicated weekly deviations from this average. The ICCs for the social interaction frequency variables ranged from .53 (for the frequency of video calls) to .67 (for the frequency of text-based digital communication).

Control variables. Control variables included participants’ age in years, gender (0 = women, 1 = men), the number of physician diagnosed health conditions during the last two years (see

supplemental material, section 1), household income (1 = up to 3000 CHF, 2 = 3001 - 4000 CHF, 3 = 4001 - 6000 CHF, 4 = 6001 - 8000 CHF, 5 = 8001 - 12000 CHF, 6 = more than 12000 CHF per month), whether they were living alone (0 = no, 1 = yes), and whether they were married (0 = no, 1 = yes), computer proficiency (Boot et al., 2015) and subjective technology adaptivity (Kamin & Lang, 2013). Computer Proficiency was measured using the Computer Proficiency Questionnaire (Boot et al., 2015) that contains 32 items. Answers indicate how well participants think they perform certain tasks on a computer on a five-point scale. The Subjective Technology Adaptivity Questionnaire (Kamin & Lang, 2013) consists of 12 questions that assesses the use and perceived usefulness of technology on a five-point scale. The items living alone and being married were highly negatively correlated ($r = -.793$), thus, only living alone was considered in our analysis in order to avoid multicollinearity. The control variables were centered at sample means. Data Analysis Data were analyzed with multilevel models based on 64 occasions of data per participant to examine associations of weekly positive affect, negative affect, and loneliness with the frequency of communication via different interaction modalities (face-to-face, video calls, telephone, digital communication like emails or text messages).

At the within-person (WP) level, the models were specified as

$$\text{Outcome}_{ti} = \beta_{0ti} + \beta_{1i}(\text{WP face-to-face interactions}_{ti}) + e_{ti} \quad (1),$$

where Outcome_{ti} , person i 's score for positive affect, negative affect, or loneliness during each week t , is a function of: β_{0ti} , a week-specific and individual-specific intercept parameter and β_{1i} , which captures the effect of the weekly frequency of face-to-face interactions. e_{ti} represents residual error. Equivalent models were set up for video-call, telephone, and text-based digital interactions.

At the between-person (BP) level, individual-specific parameters were modelled as

$$\beta_{0ti} = \gamma_{00} + \gamma_{01}(\text{BP face-to-face interactions}_{i}) + \gamma_{02}(\text{age}_{i}) + \gamma_{03}(\text{gender}_{i}) + \gamma_{04}(\text{income}_{i}) + \gamma_{05}(\text{living alone}_{i}) + \gamma_{06}(\text{health conditions}_{i}) + \gamma_{07}(\text{computer proficiency}_{i}) + \gamma_{08}(\text{subjective technology adaptivity}_{i}) + u_{0i} + u_{0t}; \quad (2)$$

$$\beta_{1i} = \gamma_{10}; \quad (3)$$

where γ_{00} represents the averages of outcome variables (positive affect, negative affect, and loneliness) across all individuals and weeks and γ_{10} represents the sample-level association between the weekly number of face-to-face interactions relative to one's own average and the

outcome variable. u_{0i} represents individual-specific deviations and u_{0t} represents week-specific deviations from the average across all individuals and weeks. Individual-specific and week-specific differences in β_{1i} were not modelled to facilitate model convergence. γ_{01} indicated the between-person association between the average face-to-face interaction frequency over 64 weeks and the outcome variable. γ_{02} to γ_{08} indicate the associations of control variables with individual differences in the outcome. Equivalent models were set up for video-call, telephone, and digital text-based interactions. Models were estimated in R (R Core Team, 2018) with the lme4 package (Bates et al., 2015). To examine whether the effect of face-to-face interactions on well-being significantly differed from the effects of telephone and digital text-based interactions, we calculated contrasts on these effects with the car package (Fox & Weisberg, 2019). Finally, to examine whether digital communication can compensate for the lack of face-to-face interaction, we constructed separate models including relevant interactions (i.e., face-to-face \times video-call; face-to-face \times telephone; face-to-face \times digital text-based), for both within- and between-person effects, and for all the three outcome variables (positive affect, negative affect, loneliness).

Results

Associations between Social Interaction Frequency and Well-Being

We hypothesized that participants with a higher frequency of face-to-face and video call interactions over the study period would experience higher well-being than participants with less frequent face-to-face or video-call interactions (between-person-level) and that the frequency of telephone or text-based digital interactions would not show similarly strong associations with well-being. For the within-person level, we expected the same associations, i.e., that during weeks with more face-to-face or video-call interaction, participants would report higher wellbeing than usual. We did not expect similar associations between the frequency of telephone or text-based digital interactions and within-person differences in well-being. Table 2 shows all results from our unconditional models examining the effects of face-to-face interaction, video-calls, telephone, and digital text-based communication separately.

In line with our hypotheses, participants who reported more face-to-face interactions than other participants also reported higher levels of positive affect ($\gamma_{01} = 4.360$, $SE = 1.639$, $p = .009$) and lower levels of negative affect ($\gamma_{01} = -5.619$, $SE = 1.910$, $p = .004$) and loneliness ($\gamma_{01} = -0.326$, $SE = 0.060$, $p < .001$) than participants with less frequent face-to-face interaction. Also in line with our hypotheses, participants showed significantly higher

levels of positive affect ($\gamma_{10} = 1.658$, $SE = 0.203$, $p < .001$) and lower levels of negative affect ($\gamma_{10} = -1.206$, $SE = 0.250$, $p < .001$) and loneliness ($\gamma_{10} = -0.052$, $SE = 0.006$, $p < .001$) than usual in weeks when they reported more frequent face-to-face interaction than usual. The same effects were also significant for the frequency of telephone and digital text-based interactions (see Table 2), which was not expected.

Contrary to our hypotheses, the frequency of video-calls was not related to positive and negative affect and loneliness at the between-person level. Participants reported lower levels of loneliness during weeks with higher frequency of video-calls ($\gamma_{10} = -0.015$, $SE = 0.008$, $p = .049$), which is in line with our hypotheses. However, contrary to our hypotheses, participants reported significantly higher levels of negative affect than usual during weeks when they reported higher frequency of video-calls than usual ($\gamma_{10} = 0.907$, $SE = 0.321$, $p = .005$). Also contrary to our hypotheses, the frequency of video-calls was not related to positive affect at the within-person level.

Table 3 shows all results from our models examining the effects of face-to-face interaction, video-calls, telephone, and digital text-based communication separately with all control variables added (age, gender, living alone, health conditions, income, computer proficiency, subjective technology adaptivity). After taking the control variables into account, most of our findings remained the same. However, the between-person effect of face-to-face interaction and the within-person effect of telephone interactions on positive affect and of video-call interaction on loneliness were no longer significant after including control variables into the analysis. Additionally, the within-person effect of video-call interactions on positive affect became significant. The effect was negative, indicating that participants reported significantly lower levels of positive affect than usual during weeks in which they reported more frequent video-calls ($\gamma_{10} = -0.900$, $SE = 0.265$, $p < .001$), which is not in line with our hypotheses.

We conducted separate analyses for all four interaction modalities because our hypotheses were related to independent effects of the interaction modalities on the three indicators of well-being. To examine the relative strength of the associations, we also conducted one analysis with all interaction modalities in one model. Results are presented in Table S1 in Section 3 in the supplemental materials. Some associations between social interaction frequency and well-being were no longer significant in this model. To summarize, at the between-person level, the effects of face-to-face interactions and text-based digital interactions on positive affect and the effects of face-to-face interactions on negative affect as

well as all between-person effects of telephone interactions were no longer significant. At the within-person level, the effects of telephone interactions on positive affect and loneliness were no longer significant.

In sum, these findings from both analyses support our hypotheses that higher frequency of face-to-face interactions would have positive effects on well-being. As hypothesized, face-to-face interaction did have positive associations with well-being at the between-person and within-person levels. However, this was not the case for video-call interactions. Further, we did not expect positive associations of the frequency of telephone and text-based interactions with well-being. Nevertheless, these associations were significant.

Participants with more health conditions reported lower levels of positive affect ($\gamma_{06} = -2.047$, $SE = 1.001$, $p = .044$) and higher levels of negative affect ($\gamma_{06} = 2.340$, $SE = 1.155$, $p = .042$). Older participants reported more loneliness ($\gamma_{02} = 0.028$, $SE = 0.013$, $p = .035$) than younger participants and participants with higher subjective technology adaptivity scores reported more negative affect ($\gamma_{08} = 0.453$, $SE = 0.206$, $p = .030$).

Table 2. Results from unconditional models examining the effects of face-to-face, video-call, telephone, and text-based digital interactions on positive and negative affect and loneliness.

	Positive Affect			Negative Affect			Loneliness		
	γ	SE	p	γ	SE	p	γ	SE	p
Fixed effects									
<i>Weekly Face-to-Face Interactions</i>									
Intercept (γ_{00})	71.408*	1.677	<.001	25.979*	1.959	<.001	1.754*	0.061	<.001
Between-Person (γ_{01})	4.360*	1.639	.009	-5.619*	1.910	.004	-0.326*	0.060	<.001
Within-Person (γ_{10})	1.658*	0.203	<.001	-1.206*	0.250	<.001	-0.052*	0.006	<.001
<i>Weekly Video-Call Interactions</i>									
Intercept (γ_{00})	71.524*	1.731	<.001	25.919*	2.041	<.001	1.751*	0.069	<.001
Between-Person (γ_{01})	2.620	2.459	.289	1.202	2.901	.680	-0.126	0.099	.210
Within-Person (γ_{01})	-0.289	0.261	.269	0.907*	0.321	.005	-0.015*	0.008	.049
<i>Weekly Telephone Interactions</i>									
Intercept (γ_{00})	71.549*	1.707	<.001	25.861*	2.005	<.001	1.750*	0.067	<.001
Between-Person (γ_{01})	3.738*	1.831	.044	-4.426*	2.149	.042	-0.189*	0.073	.011
Within-Person (γ_{10})	0.506*	0.217	.020	-0.847*	0.267	.002	-0.017*	0.006	.009

Weekly Text-Based Digital Interactions

Intercept (γ_{00})	71.546*	1.653	<.001	25.878*	1.959	<.001	1.751*	0.060	<.001
Between-Person (γ_{01})	5.498*	1.640	.001	-6.007*	1.943	0.003	-0.351*	0.060	<.001
Within-Person (γ_{10})	1.227*	0.239	<.001	-1.703*	0.294	<.001	-0.031*	0.007	<.001

Notes: $n = 98$; 4,512 observations; γ = Estimate; SE = Standard Error; $p < .05$

Table 3. Results from models examining the effects of face-to-face, video-call, telephone, and text-based digital interactions on positive and negative affect and loneliness with added control variables.

	Positive Affect			Negative Affect			Loneliness		
	γ	SE	p	γ	SE	p	γ	SE	p
Fixed effects									
<i>Weekly Face-to-Face Interactions</i>									
Intercept (γ_{00})	71.398*	1.642	<.001	25.987*	1.902	<.001	1.754*	0.058	<.001
Between-Person (γ_{01})	3.544	1.829	.056	-5.449*	2.112	.012	-0.259*	0.065	<.001
Within-Person (γ_{10})	1.658*	0.203	<.001	-1.206*	0.250	<.001	-0.051*	0.006	<.001
<i>Weekly Video-Call Interactions</i>									
Intercept (γ_{00})	71.089*	1.637	<.001	26.150*	1.918	<.001	1.755*	0.063	<.001
Between-Person (γ_{01})	2.453	2.635	.354	0.502	3.087	.870	-0.054	0.100	.592
Within-Person (γ_{10})	-0.900*	0.265	<.001	1.510*	0.325	<.001	-0.003	0.008	.741
<i>Weekly Telephone Interactions</i>									
Intercept (γ_{00})	71.549*	1.707	<.001	26.145*	1.866	<.001	1.756*	0.056	<.001
Between-Person (γ_{01})	4.300*	1.822	.021	-4.763*	2.121	.033	-0.242*	0.067	.001
Within-Person (γ_{10})	0.161	0.222	.468	-0.581*	0.272	.033	-0.013*	0.006	.040

	<i>Weekly Text-Based Digital Interactions</i>								
Intercept (γ_{00})	71.099*	1.570	<.001	26.136*	1.819	<.001	1.755*	0.053	<.001
Between-Person (γ_{01})	5.108*	1.765	.005	-6.432*	2.045	.002	-0.343*	0.059	<.001
Within-Person (γ_{10})	0.824*	0.246	<.001	-1.267*	0.301	<.001	-0.026*	0.007	<.001
	<i>Control Variables</i>								
Age (γ_{02})	-0.141	0.362	.699	-0.086	0.418	.840	0.028*	0.013	.035
Gender (γ_{03})	-4.642	3.864	.234	1.348	4.465	.764	-0.114	0.138	.412
Income (γ_{04})	0.802	1.343	.552	0.870	1.551	.576	0.038	0.048	.430
Living Alone (γ_{05})	-0.069	4.170	.986	-3.638	4.813	.452	0.121	0.149	.421
Health Conditions (γ_{06})	-2.047*	1.001	.044	2.340*	1.155	.042	0.056	0.036	.0124
Computer Proficiency (γ_{07})	0.074	0.099	.457	-0.161	0.114	.162	-0.004	0.004	.273
Subjective Technology Adaptivity (γ_{08})	-0.296	0.178	.100	0.453*	0.206	.030	0.003	0.006	.529

Notes: γ = Estimate; SE = Standard Error; $p < .05$

Do Effects Differ Across Interaction Modalities?

We further hypothesized that face-to-face interactions would have uniquely stronger positive impact on well-being than other interaction modalities. To test this, we conducted chi² tests to examine whether the effect of face-to-face interactions on positive affect, negative affect and loneliness differed significantly from those of video-calls, telephone calls, and digital text based interactions. Results are reported in Table 4.

Between-person level. At the between-person level, the effect of face-to-face interaction on negative affect was significantly stronger than the effect of video-calls ($\chi^2(1) = 4.857$, $p = .028$). The between person effect of face-to-face interaction on loneliness differed significantly from the effects of video-calls ($\chi^2(1) = 4.680$, $p = .031$). All other effects did not differ significantly from each other. Taken together, these findings did not support our hypothesis that the frequency of telephone and text-based digital interactions would show weaker associations with well-being than the frequency of face-to-face interactions at the between-person level.

Within-person level. At the within-person level, the effect of face-to-face interactions on positive affect was significantly stronger than the effects of video-calls ($\chi^2(1) = 35.039$, $p < .001$) and of telephone interactions ($\chi^2(1) = 16.699$, $p < .001$). The effect of face-to-face interactions on negative affect at the within-person level also differed significantly from the effect of video-call interactions ($\chi^2(1) = 27.031$, $p < .001$): Weeks with higher frequency of face-to-face interactions were associated with lower negative affect whereas weeks with higher frequency of video-calls were associated with higher negative affect. Regarding the effects on loneliness at the within-person level, the effect of face-to-face interaction frequency was significantly stronger than the effects of the frequency of video-calls ($\chi^2(1) = 14.764$, $p < .001$), telephone calls ($\chi^2(1) = 18.40$, $p < .001$), and digital text-based interactions ($\chi^2(1) = 6.309$, $p = .012$). All other effects did not differ significantly from each other. Taken together, these findings support our hypothesis that the frequency of telephone and text-based digital interactions would show weaker associations with well-being than the frequency of face-to-face interactions at the within-person level. We found support for this hypothesis for some, but not all of the outcomes. At the within-person level, effects of face-to-face interactions were significantly stronger than effects of all other interaction modalities for loneliness, suggesting that face-to-face interaction is especially important to minimize the feeling of loneliness.

Table 4. Results from χ^2 tests examining differences between face-to-face interaction frequency vs. other interaction modalities

	<i>df</i>	χ^2	<i>p</i>	<i>df</i>	χ^2	<i>p</i>
<i>positive affect</i>						
	<i>between-person</i>			<i>within-person</i>		
face-to-face vs video-call	1	0.565	.452	1	35.039	< .001
face-to-face vs. telephone	1	0.135	.714	1	16.699	< .001
face-to-face vs. digital text-based interaction	1	0.345	.557	1	2.533	.115
<i>negative affect</i>						
	<i>between-person</i>			<i>within-person</i>		
face-to-face vs- video-call	1	4.857	.028	1	27.031	< .001
face-to-face vs- telephone	1	0.311	.577	1	1.094	.296
face-to-face vs. digital text-based interaction	1	0.024	.878	1	1.576	.209
<i>Loneliness</i>						
	<i>between-person</i>			<i>within-person</i>		
face-to-face vs. video-call	1	4.680	.031	1	14.764	< .001
face-to-face vs. telephone	1	3.640	.056	1	18.40	< .001
face-to-face vs. digital text-based interaction	1	0.110	.741	1	6.309	.012

Notes: : $n = 98$; 4,512 observations. SE = standard error. *df* = degrees of freedom

Compensatory Role of Video-Calls, Telephone Calls, and Text-Based Digital Interactions

We examined possible compensatory effects of the interaction modalities of video-call, telephone, and digital text-based interactions. Specifically, we tested whether during weeks with less frequent face-to-face interactions, the frequency of other interaction modalities could buffer negative effects on well-being. These results can be found in Table 5. We found two significant interaction effects. These interaction effects are illustrated in Figure 1. At the within-person level, the interaction effect of face-to-face and telephone calls ($\gamma = 0.019$, $SE = 0.005$, $p < .001$) was significant for loneliness. The same effect was also found for the interaction of face-to-face and text-based digital communication at the within-person level for loneliness ($\gamma = 0.011$, $SE = 0.005$, $p = .048$). That is, during weeks with little face-to-face contact, communicating via telephone, email, or text can compensate for the lack of face-to-face contact in terms of loneliness. However, the interaction effect of face-to-face interaction and video-calls was not significant, neither for positive and negative affect nor for loneliness. To conclude, we found partial support for this hypothesis, indicating that telephone and text based digital interactions can compensate for a lack of face-to-face contact for one of the outcomes.

Table 5. Results from models examining moderating effects of face-to-face interactions.

Fixed effects	Positive Affect		Negative Affect		Loneliness	
	γ	SE	γ	SE	γ	SE
<i>Face-to-Face Interactions x Video-Call Interactions – Between-Person</i>						
Intercept	72.491*	1.700	27.015*	1.984	1.748*	0.061
Face-to-Face Interactions	4.167*	1.658	-5.663*	1.934	-0.522*	0.061
Video-Call Interactions	1.974	2.438	2.209	2.845	-0.091	0.089
Face-to-Face Interactions x Video-Call Interactions	0.536	2.196	-1.559	2.565	0.049	0.080
<i>Weekly Face-to-Face Interactions x Weekly Video-Call Interactions – Within-Person</i>						
Intercept	72.080*	1.427	26.987*	2.031	1.754*	0.069
Face-to-Face Interactions	1.621*	0.203	-1.192*	0.250	-0.053*	0.006
Video-Call Interactions	-0.218	0.262	0.884*	0.323	-0.014	0.008
Face-to-Face Interactions x Video-Call Interactions	0.490	0.283	-0.065	0.349	0.014	0.008
<i>Face-to-Face Interactions x Telephone Interactions – Between-Person</i>						
Intercept	72.080*	1.717	27.357*	2.009	1.760*	0.062
Face-to-Face Interactions	4.047*	1.696	-5.243*	1.984	-0.307*	0.062
Telephone Interactions	2.474	1.861	-2.843	2.176	-0.105	0.068
Face-to-Face Interactions x Telephone Interactions	2.060	1.831	-2.105	2.140	-0.038	0.080

Weekly Face-to-Face Interactions x Weekly Telephone Interactions - Within-Person

Intercept	72.423*	1.728	26.943*	2.028	1.753*	0.069
Face-to-Face Interactions	1.633*	0.203	-1.156*	0.250	-0.050*	0.006
Telephone Interactions	0.386	0.217	-0.765*	0.268	-0.012	0.006
Face-to-Face Interactions x Telephone Interactions	0.053	0.189	-0.026	0.233	0.023*	0.005

Face-to-Face Interactions x Digital Text-Based Interactions - Between-Person

Intercept	72.115*	1.706	26.781*	2.16	1.745*	0.058
Face-to-Face Interactions	3.003	1.692	-4.062*	2.000	-0.236*	0.008
Text-Based Digital Interactions	4.851*	1.757	-4.544*	2.077	-0.266*	0.061
Face-to-Face Interactions x Text-Based Digital Interactions	1.280	1.480	0.367	1.750	-0.021	0.051

Weekly Face-to-Face Interactions x Weekly Digital Text-Based Interactions - Within-Person

Intercept	72.434*	11.730	26.957*	2.033	1.755*	0.056
Face-to-Face Interactions	1.560*	0.203	-1.085*	0.251	-0.049*	0.006
Digital Text-Based Interactions	1.023*	0.242	-1.614*	0.298	-0.024*	0.007
Face-to-Face Interactions x Text-Based Digital Interactions	-0.1403	0.199	-0.154	0.245	0.011*	0.006

Notes: $n = 98$; 4,512 observations. SE = standard error ; * $p < .05$

The Role of COVID-19 Restrictions

We conducted further analyses to understand the role of COVID-19 restrictions over the study period. Toward this end, we created a binary variable indicating whether the data collection took place in a week where strong restrictions were in place (0 = no, 1 = yes) and centered it at the mean of all observations. Further information related to this variable is reported in Supplemental Material, section 2. Results from analyses including this variable are reported in Table S6. After controlling for this variable, the significance of the between person and the within-person effects of all four interaction modalities remained the same with one exception. The effect of video-call frequency on loneliness was no longer significant ($\gamma = -0.014$, $SE = 0.008$, $p = .068$). We also tested for interaction effects between the binary restriction variable and the weekly communication frequency variables via different modalities. We found significant interaction effects for the weekly frequency of text-based digital interactions for positive affect ($\gamma = 2.171$, $SE = 0.514$, $p < .001$), negative affect ($\gamma = -1.251$, $SE = 0.632$, $p = .048$), and loneliness ($\gamma = -0.038$, $SE = .015$, $p = .010$). The interaction effects indicated that the positive effects of a higher frequency of text-based digital interaction on well-being (within-person) were even stronger during times when strong restrictions were in place.

Cross-lagged Associations

Additional analyses examined lead-lag associations between social interaction frequency and well-being while controlling for the role of governmental restrictions. These analyses were performed with the lavaan package (Rosseel 2012) in R. We created lag variables for positive affect, negative affect, loneliness, and the frequency of all four interaction modalities. Results are reported in Tables S2 – S5 in Section 3 in the Supplemental materials. Regression coefficients for autoregressive effects indicate that well-being and the frequency of use of interaction modalities were stable over time and can therefore be predicted by the scores of the previous week.

Cross-lagged regression coefficients indicated that a higher frequency of face-to-face interactions in the previous week was associated with lower scores in loneliness ($\gamma = -0.015$, $SE = 0.006$, $p = .007$) in the following week. A higher frequency of video-calls was associated with lower levels of positive affect ($\gamma = -0.862$, $SE = 0.253$, $p = .001$), and higher levels of negative affect ($\gamma = 1.146$, $SE = 0.307$, $p < .001$) and loneliness ($\gamma = 0.015$, $SE = 0.007$, $p = .037$) in the following week.

Higher levels of positive affect in the previous week were associated with a higher frequency of face-to-face interactions ($\gamma = 0.007$, $SE = 0.001$, $p < .001$) in the following week. Higher levels of negative affect in the previous week were associated with a lower frequency of face-to-face interactions ($\gamma = -0.002$, $SE = 0.001$, $p = .006$), but with a higher frequency of video-calls ($\gamma = 0.002$, $SE = 0.001$, $p = .007$) in the following week. Higher levels of loneliness in the previous week were associated with a lower frequency of face-to-face interactions ($\gamma = -0.109$, $SE = 0.039$, $p = .005$) and text-based digital interactions ($\gamma = -0.083$, $SE = 0.032$, $p = .010$) in the following week.

Discussion

The goal of the present study was to investigate the role of social interaction frequency via four different modalities (face-to-face, video-call, telephone, and text-based digital) on well-being (positive and negative affect and loneliness) in older adults during the COVID-19 pandemic. Further, we examined whether interactions via video-call, telephone, and text based digital communication can compensate for lack of face-to-face communication.

Social Interactions and Well-Being: The Role of Modality

Mostly, our results are in line with our hypotheses and results by prior research (e.g. Sacco & Ismail, 2014; Lin & Lachman, 2021; Sun et al., 2020). In sum, our results show that higher frequency of face-to-face social interaction was associated with more positive affect and less negative affect and loneliness both on the between- and the within-person level. Contrary to our hypotheses, we found the same associations also for telephone and text-based digital social interactions. However, some of the effects of social interaction frequency were stronger for face-to-face vs. other interactions. Higher frequency of video-calls was unrelated to well-being at the between-person level and associated with more negative affect and less loneliness at the within-person level. Interaction effects indicated that higher frequencies of telephone and text-based digital exchanges may compensate for lack of face-to-face exchanges for loneliness at the within-person level. When considering the effects of COVID restrictions, most results remained the same except that the effect of frequency of video-calls on loneliness was no longer significant. Further, we found a significant interaction effect between COVID-19 restrictions and weekly frequency of text-based digital exchanges on positive and negative affect and loneliness, indicating that the effects were stronger when more restrictions were in place. As regards cross-lagged associations, higher levels of face-to face interactions in the previous week were associated with less loneliness in the following week and higher levels of video-call interactions were associated with less positive affect and more negative affect and

loneliness in the following week. Taken together, concurrent associations between social interaction frequency, well-being, and loneliness were more consistent than the effects of previous social interaction frequency on subsequent well-being and loneliness. In the opposite direction, more positive affect in the previous week was associated with higher frequency of face-to-face interactions in the following week. More negative affect in the previous week was associated with lower frequency of face-to-face and higher frequency of video-call interactions in the following. More loneliness in the previous week was associated with lower frequency of face-to-face and text-based digital interactions in the following week. In summary, these findings do not support the hypothesis that people may seek out more social interaction when experiencing bad mood or feeling lonely, to the opposite, there is some evidence that they may be even less likely to seek out social interaction.

To our knowledge, there are no other studies that have investigated the effect of video calls on older adults' well-being and loneliness in a similar way. In general, results from previous studies on the association between video-calls and well-being and the possible compensatory role for video call interactions is heterogenous and difficult to interpret. Most other studies did not examine video-calls as an interaction modality (Lin & Lachman, 2021), summarized video-calls, emails, and social media chats as "digital communication" (Kim & Fingerman, 2022; Macdonald et al., 2021; Skalacka & Pajestka, 2021), or data on communication was collected retrospectively at one point in time (Tomaz et al., 2021). While these methodological differences make it difficult to interpret the unexpected results for the effects of video-calls on our participants' well-being, we note several possible explanations. First, it is possible that video-calls have a negative connotation as the use of this interaction modality increased heavily during the pandemic: The same sample of participants barely used video-calls in 2019 (Macdonald et al., 2021). The outbreak of the pandemic was associated with increased stress (Whitehead & Torossian, 2021) and it is possible that video-calls as an interaction modality are highly linked to these experiences. This may also be related to the second possibility, namely the perceived novelty of video-call as an interaction modality because participants may be familiar with what to expect after a telephone call or an exchanged email but have to get used to the discrepancy of engaging in a rich interaction modality while being physically alone. And third, related to the novelty of video calls, it is also possible that participants knew how to perform a video-call technically, but experienced a lack of familiarity with this interaction modality which limits possible positive effects of these interactions due to perceived stress or pressure during the interaction. Further, in our study, the frequency of face-to-face, telephone, and text-based interactions were all correlated,

whereas the frequency of video-call interactions was not correlated with the other modalities. Taken together, these findings suggest that video calls are distinct from other social interaction modalities and are not in line with perspectives that emphasize the role of richness of information. Theoretical perspectives should take specific features of interaction modalities into account. Communicating via video-calls is comparably new. Future research should include measurements of more direct effects and consider the reasons behind choosing video calls to communicate.

Our analysis showed that the effects of face-to-face interaction on loneliness were significantly stronger than the effects of most other interaction modalities at the within-person level. These findings suggest that it may be beneficial to compensate for lack of face-to-face interactions via alternative digital interaction modalities. With the compensation effects of frequent telephone and text-based digital interactions during times when face-to-face interactions were less frequent, it becomes clear that telephone and text-based interactions should not be viewed as irrelevant for well-being. These interaction modalities can be especially beneficial in times when communication via richer interaction modalities is not possible. These results are in line with the perspective of the media multiplexity theory that any form of medium can facilitate interpersonal relationships and be beneficial for well-being (Haythornthwaite, 2005). However, it needs to be noted that the compensation was only partial, as participants still reported a decrease in well-being during times when face-to-face interaction was lower. So, it appears, as noted in Hall et al. (2022), that even though digital interaction is better than no interaction, those media tools cannot satisfy well-being and the feeling of belongingness as well as face-to-face contact. This is in line with Media Richness Theory (Daft & Lengel, 1983), as it postulates that face-to-face interactions are richest in information. Compensatory effects were found for telephone and digital text-based social interactions only for the outcome of loneliness and only at the within-person level. Frequent face-to-face interactions therefore remain crucial for overall well-being. Digital interactions can be seen as complementary interaction modalities, but cannot replace face-to-face contact.

Hall et al. (2022) argued that feelings of loneliness could serve as a motivation to seek more interaction with others. Our findings based on cross-lagged associations did not support this hypothesis. To the contrary, feelings of loneliness in the previous week were associated with less frequent face-to-face and text-based digital interactions in the following week, and negative affect was associated with less frequent face-to-face interactions the following week. While negative affect in the previous week was associated with more video calls the

following week, video calls were not associated with less negative affect in the subsequent week. To the contrary, previous frequency of video calls was associated with lower well-being (lower positive affect, higher negative affect, and loneliness) in the subsequent week. While people may have turned to video calls to improve their mood, there is little evidence in our data that video calls were helpful. Only the frequency of face-to-face social interactions predicted lower levels of loneliness in the following week. Taken together, our findings suggest that people may need to be encouraged to seek interaction when they are feeling low, because they may be less likely to do so themselves.

Digital Communication During the COVID-19 Pandemic and Beyond

As our data were collected during the acute phase of the COVID-19 pandemic, it may be argued that the implications of our results for non-pandemic times are limited. However, our results on the effects of the different interaction modalities were mostly consistent when considering different phases in the pandemic based on national restrictions. Our findings indicated that the effects of text-based interaction were higher when stricter national restrictions were in place; however, the main effects of text-based communication were significant even during average weeks. Due to digitalization of our society, digital communication becomes more and more important also for older generations and the results carry a relevance in the post-pandemic world. As challenging as these pandemic years have been, it seems possible that people, especially the older generation, will pick up and continue to adapt their communication behaviors towards more digital communication. Once this age group has adopted more digital ways of communicating and experienced positive results, they may see it as a potential compensating mechanism. Our and other results show benefits of digital communication for well-being (Gaia et al., 2021; Lin & Lachman, 2021) implying that it should be encouraged and promoted further.

Interestingly, our results for telephone and digital text-based interactions differ from the results of a previous study of which our study examined a subsample (Macdonald et al., 2021). Data for that study were collected in 2019 before the outbreak of the COVID-19 pandemic. Possible reasons for this discrepancy are the different circumstances under which data were collected (pandemic vs. pre-pandemic) as well as methodological differences in data collection. While considering the strictness of COVID-19 restrictions did not affect most of our findings, the effects of text-based communication were stronger during times with more restriction (but not exclusively during these time periods). In 2019, data on social interactions and well-being were collected daily, whereas our 2020-21 data were collected on

a weekly basis. Possibly, one interval is better suited for detecting associations between communication frequency and well-being than the other. Further research in this area would be fruitful. In addition, the feeling of social isolation in the current study may have been reinforced not only by lack of physical closeness and social connectedness but also by worries about the pandemic and personal loss experienced in connection to the pandemic.

Limitations and Outlook

In closing, we note some limitations of the present study. First, the present study did not collect data at the interaction level. Previous studies have indicated that interaction partners and content of the interaction had impact on the perceived pleasantness of the interaction which was linked to several momentary indicators of health and well-being like happiness, tiredness, and sadness and loneliness (e.g. Skalacka & Pajestka, 2021; Chen & Freeley, 2014). Our participants may have experienced joy during the video-call interaction but felt lonelier afterwards compared to the feeling after a face-to-face interaction which may have made the discrepancy of actual in-person contact and virtual contact more noticeable. However, we did not measure immediate reaction and well-being after the interactions and can therefore only speculate about immediate feelings and the persistence of positive or negative outcomes from these interactions. Further, a study by Skalacka and Pajestka (2021) showed that mental health of older adults was more closely related to the frequency of contact with their children and grandchildren compared to contact with friends or more distant social contacts. Our analysis did not differentiate between closeness of relationship but only differentiated between modes of contact. The relationship to the interaction partner as well as the perceived pleasantness of the interaction itself probably also impacts the effect the interaction has on a person's well-being. In addition, we did not measure the length of the interaction which could also influence the perceived pleasantness in both directions. It would also be interesting to gain more insights into why certain interaction modalities are chosen: Were video-calls, telephone calls or digital interactions actively chosen (more often) as a compensation for less frequent face-to-face contact? Do the reasons for scheduling a video call or sending an email differ and to what extent? Information on these questions could help to further explain differential effects of the interaction modalities. Further, different providers of video-calls offer different set-ups and visuals, e.g., the size of the window frame in which one sees oneself and the other person, or how well they work when talking to two or more people. Self-monitoring and the size in which one can see the interaction partner may also play a role in how video-calls are

perceived. Future research on video-calls should address which advantages and disadvantages of specific format features for well-being and perceived relationship and interaction quality.

Another limitation is that our participants reported about their interactions and well-being during the last week. Most other studies that investigated a similar research question as ours used daily assessments of well-being and social interactions over a shorter time period. While the weekly assessment was advantageous in collecting data over a longer time period, the downside is that our results are based on retrospective assessments and therefore prone to memory biases. However, Neubauer et al. (2020) found that the memory-experience gap for negative affect is less intense in older age and that there is also only a small memory experience gap for positive affect. Although we included the strictness of governmental restrictions as a control variable, we do not know whether participants felt more or less at risk or frightened by the pandemic during certain weeks of data collection. Additionally, we did not consider local variations of governmental restrictions.

The measurements we used for assessing well-being and loneliness were developed to measure between-person variation. It is yet to be evaluated whether such instruments also measure within-person variations comparably well (Brose et al., 2020). While the within person reliability was acceptable for positive and negative affect, the within-person reliability for the loneliness scale was relatively low. We note two possible reasons for this finding: First, positive and negative affect were measured on a 0-100 scale, whereas loneliness was assessed on a 5-point scale, which may have caused less possibility for intraindividual variation for the loneliness scale. Second, the positive and negative affect items were related to momentary affective experiences, whereas the loneliness scale included items related to more general perceptions (e.g., “There are people I feel close to”; “I feel like I belong to a circle of friends”). In line with these interpretations, the intraclass correlations indicated that there was relatively more variability between participants (vs. within participants) in loneliness relative to positive and negative affect. Results must therefore be interpreted with caution. Further, it should be a priority for future research to develop and choose appropriate measurements that are feasible for between- and within-person assessments (Brose et al. 2020) and identify for which time intervals the measurements are best suited.

We note that our findings regarding video-call should be interpreted with caution, as video-calls were rarely used by our participants. This could also be reason for the lack of significant associations of frequency of video-calls with well-being and loneliness at the between-person level. In order to better understand the effects of video calls on well-being, it

may be helpful to make use of experimental designs, because video calls are currently infrequently used in the daily lives of older adults. Participants were recruited on a voluntary basis, had relatively high levels of education and were familiar with technology and digital communication prior to our study. It is therefore uncertain whether our results can be generalized to other groups of older adults, for example, those at high risk for social isolation or with physical disabilities. Shorter time intervals (e.g. daily data collection instead of weekly collection) may be better suited as reciprocal association likely operate on faster time scales.

Conclusion

The COVID-19 pandemic and concomitant restrictions can be considered a major stressor for older adults. In general, participants with more frequent contact to others reported higher well-being than participants with less frequent contact to others. Also, weeks during which participants reported more social interaction were generally associated with higher well-being. Our results show that these effects are dependent on the interaction modality. Interacting face-to-face, via telephone, and text were positively associated with participants' well-being. Video-calls on the other hand, had an unexpected negative association with well-being. Future research should examine potential reasons for this unexpected finding. Telephone and text-based digital interactions buffered feelings of loneliness during times of infrequent face-to-face interactions. Taken together, these findings deliver insights that can be used to develop interventions to prevent and reduce feelings of loneliness and to facilitate well-being.

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Appendix: Supplemental Online Materials

Section 1. Measurement of Health Conditions

Question: *Have you suffered from the following diseases / symptoms in the past 2 years or have you been treated for them?*

Answer Options:

Asthma, bronchitis, emphysema of old age
Tuberculosis
Lung complaints
Arthritis, rheumatism or other diseases of the bone apparatus
Lumbago, recurrent back pain
Persistent (persistent) skin problems (e.g. eczema)
Thyroid gland diseases
High fever
Recurring stomach problems, diarrhea
Gall bladder problems
Problems with blood vessels
AIDS, HIV infection
Lupus or other autoimmune diseases
Toothache
High / low blood pressure
Anxiety, depression, or other emotional illness
Alcohol or drug problems
Migraine
Chronic sleep problems
Diabetes
Multiple sclerosis, epilepsy or other neurological diseases
Stroke
Cancer

Section 2. Governmental restrictions in Switzerland during data collection

Date	Week of Data collection	Restricting / Relaxing	Measures (excerpts)
2020-03-30	1-6	restricting	Restricting public life, commuting, meetings etc.
2020-05-11	7	relaxing	Re-opening of restaurants and museums Re-opening of parks, zoos, swimming pools
2020-06-06	11	relaxing	+ relaxed rules for vulnerable populations
2020-06-22	13	relaxing	Abolition of restrictions on number of people in a meeting (30+)
2020-10-29	31	restricting	Prohibition of choir meetings, limitations for private and public gatherings (no more than 15 people allowed)
2020-12-12	38	restricting	restricted opening times of restaurants, meeting only with one other household, limited guests for funerals, curfew
2020-12-22	39	restricting	Closing of restaurants
2021-01-13	41	restricting	Private meetings only for maximum 5 people (including children), closing of shops (excluding supermarkets, pharmacies)
2021-02-24	47	relaxing	Private meetings for up to ten people, re-opening of shops, parks, zoos
2021-04.19	54	relaxing	Private meetings up to 15 people, public events (culture or sport related) with mandatory face masks
2021-05-31	61	relaxing	Private and public meetings with up to 50 people possible, sport and cultural events without restrictions

Source:

Bundesamt für Gesundheit BAG: *Gesetzgebung Covid-19*. Der Bundesrat. Last retrieved 2023, 23rd October from <https://www.bag.admin.ch/bag/de/home/krankheiten/ausbrueche-epidemien-pandemien/aktuelle-ausbrueche-epidemien/novel-cov/massnahmen-des-bundes.html>

Section 3. Additional Analyses

Table S1. Results from models examining the effects of face-to-face, video-call, telephone, and digital interactions on positive and negative affect and loneliness conjointly in one model.

	Positive Affect			Negative Affect			Loneliness		
	γ	SE	p	γ	SE	p	γ	SE	p
Fixed effects									
Intercept (γ_{00})	71.438*	1.567	<.001	25.955*	1.870	<.001	1.753*	0.052	<.001
<i>Weekly Face-to-Face Interactions</i>									
Between-Person (γ_{01})	2.129	1.903	.266	-3.744	2.223	.096	-0.171*	0.0622	.007
Within-Person (γ_{10})	1.550*	0.203	<.001	-1.035*	0.250	<.001	-0.049*	0.006	<.001
<i>Weekly Video-Call Interactions</i>									
Between-Person (γ_{01})	3.034	2.568	.241	-0.308	3.001	.916	-0.088	0.084	.299
Within-Person (γ_{01})	-0.303	0.259	.242	0.947*	0.319	.003	-0.015*	0.008	.049
<i>Weekly Telephone Interactions</i>									
Between-Person (γ_{01})	1.152	2.180	.595	-0.684	2.521	.787	-0.022	0.071	.753
Within-Person (γ_{10})	0.295	0.218	.174	-0.649*	0.268	.015	-0.010	0.006	.107
<i>Weekly Text-based digital Interactions</i>									
Between-Person (γ_{01})	4.144	2.087	0.050	-5.076*	2.437	.042	-0.292*	0.068	<.001
Within-Person (γ_{10})	1.019*	0.240	<.001	-1.518*	0.296	<.001	-0.025*	0.007	<.001

	Positive Affect			Negative Affect			Loneliness		
	γ	SE	p	γ	SE	p	γ	SE	p
<i>Control Variables</i>									
Age (γ_{02})	-0.107	0.374	.775	-0.191	0.437	.663	0.022	0.012	.080
Gender (γ_{03})	-1.989	3.908	.612	-1.802	4.562	.694	-0.291*	0.128	.028
Income (γ_{04})	0.584	1.378	.673	0.802	1.609	.619	0.045	0.045	.322
Living Alone (γ_{05})	1.176	4.102	.775	-4.190	4.789	.384	0.075	0.134	.579
Health Conditions(γ_{06})	-2.126*	0.972	.031	2.465*	1.135	.033	0.060	0.032	.063
Computer Proficiency (γ_{07})	0.034	0.097	.728	-0.116	0.114	.309	-0.001	0.003	.694
Subjective Technology Adaptivity (γ_{08})	-0.342	0.178	.059	0.478*	0.208	.024	0.006	0.006	.323

Notes: γ = Estimate; SE = Standard Error; $p < .05$.

Table S2. Results from models examining the effects of face-to-face, video-call, telephone, and digital interactions on positive and negative affect and loneliness under consideration of COVID-19 restrictions.

	Positive Affect			Negative Affect			Loneliness		
	γ	SE	p	γ	SE	p	γ	SE	p
Fixed effects									
<i>Weekly Face-to-Face Interactions</i>									
Intercept (γ_{00})	71.382*	1.665	<.001	25.965*	1.938	<.001	1.755*	0.061	<.001
Between-Person (γ_{01})	4.351*	1.639	.009	-5.589*	1.910	.004	-0.326*	0.060	<.001
Within-Person (γ_{10})	1.650*	0.206	<.001	-1.147*	0.254	<.001	-0.051*	0.006	<.001
Restricted times	-3.429*	0.616	<.001	4.939*	0.701	<.001	0.047*	0.017	.009
F2F (WP)*restricted times	-0.120	0.418	.632	-0.062	0.515	.904	0.009	0.012	.473
<i>Weekly Video-Call Interactions</i>									
Intercept (γ_{00})	71.493*	1.716	<.001	25.934	2.018	<.001	1.751*	0.069	<.001
Between-Person (γ_{01})	2.624	2.458	.288	1.180	2.901	.685	-0.126	0.099	.206
Within-Person (γ_{10})	-0.293	0.263	.265	0.942*	0.323	.004	-0.014	0.008	.068
Restricted times	-3.808*	0.658	<.001	5.162*	0.705	<.001	0.062*	0.018	.001
Video call (WP)*restricted times	0.053	0.543	.923	-0.574	0.666	0.389	-0.023	0.016	.150

	γ	SE	p	γ	SE	p	γ	SE	p
Fixed effects									
	<i>Weekly Telephone Interactions</i>								
Intercept (γ_{00})	71.517*	1.692	<.001	25.876	1.980	<.001	1.751*	0.077	<.001
Between-Person (γ_{01})	3.735*	1.831	.044	-4.435*	2.149	.042	-0.189*	0.073	.011
Within-Person (γ_{10})	0.502*	0.217	.021	-0.856*	0.266	.001	-0.017*	0.066	.007
Restricted times	-3.871	0.671	<.001	5.314*	0.726	<.001	0.061*	0.018	.001
Telephone (WP) *restricted times	0.073	0.462	.875	-0.480	0.567	.397	-0.014	0.013	.309
	<i>Weekly Text-based digital Interactions</i>								
Intercept (γ_{00})	71.489*	1.638	<.001	25.903*	1.935	<.001	1.751*	0.060	<.001
Between-Person (γ_{01})	5.511*	1.639	.001	-6.007*	1.944	.003	-0.351*	0.060	<.001
Within-Person (γ_{10})	1.247*	0.239	<.001	-1.707*	0.293	<.001	-0.032*	0.007	<.001
Restricted times	-3.974*	0.687	<.001	5.395*	0.740	<.001	0.063*	0.018	<.001
Digital text-based (WP)*restricted times	2.172*	0.514	<.001	-1.251*	0.632	0.048	-0.038*	0.015	.010

Notes: γ = Estimate; SE = Standard Error; $p < .05$.

Table S3. Results from cross-lagged models examining reciprocal associations of face-to-face interactions with positive and negative affect and loneliness

	Positive Affect			Negative Affect			Loneliness				
	Estimate	SE	Std.all	Estimate	SE	Std.all	Estimate	SE	Std.all		
<i>Within Persons</i>											
<i>Regressions</i>				<i>Regressions</i>			<i>Regressions</i>				
PA → ~ lagPA	0.373*	0.015	0.360	NA → lagNA	0.359*	0.014	0.341	LO ~ lagLO	0.343*	0.014	0.341
F2F →	-2.689*	.328	-0.115	F2F →	3.642*	0.404	0.048	F2F →	0.031*	0.009	0.127
Restr.times				Restr.Times				Restr.Times			
F2F → lagF2F	0.258*	0.015	0.245	F2F ~ lagF2F	0.265*	0.015	0.252	F2F ~ lagF2F	0.263*	0.015	0.250
Restr.times	-0.192*	0.025	-0.111	Restr.Times	-0.197*	0.025	-0.114	Restr.Times	-0.201*	0.025	-0.116
PA → lagF2F	0.372	0.200	0.026	NA → lagF2F	-0.067	0.243	-0.004	LO → lagF2F	-0.015*	0.006	-0.059
F2F → lagPA	0.006*	0.001	0.074	F2F → lagNA	-0.002*	0.001	-0.040	F2F → lagLO	-0.109*	0.039	-0.041
<i>Covariances</i>				<i>Covariances</i>				<i>Covariances</i>			
PA ↔ F2F	0.880*	0.124	0.109	NA ↔ F2F	-0.0614*	0.151	-0.062	LO ↔ F2F	-0.027*	0.004	-0.117
<i>Variances</i>				<i>Variances</i>				<i>Variances</i>			
PA	105.325*	2.267	0.841	NA	157.686*	3.394	0.844	LO	0.087*	0.002	0.872
F2F	0.622*	0.013	0.907	F2F	0.625*	0.013	0.910	F2F	0.625*	0.013	0.910
<i>Between Persons</i>											
<i>Covariances</i>				<i>Covariances</i>				<i>Covariances</i>			
PA ↔ F2F	4.582*	1.752	0.281	NA ↔ F2F	-5.315*	2.047	-0.280	LO ↔ F2F	-0.317*	0.075	-0.084
<i>Variances</i>				<i>Variances</i>				<i>Variances</i>			
PA	277.553*	40.339	1.000	NA	375.741*	54.894	1.000	LO	0.450*	0.065	1.000
F2F	0.959*	0.142	1.000	F2F	0.960*	0.142	1.000	F2F	0.954*	0.141	1.000

Notes: SE = Standard Error; $p < .05$.

Table S4. Results from cross-lagged models examining reciprocal associations between video-call interactions and positive and negative affect and loneliness.

	Positive Affect			Negative Affect			Loneliness				
	Estimate	SE	Std.all	Estimate	SE	Std.all	Estimate	SE	Std.all		
<i>Within Persons</i>											
<i>Regressions</i>				<i>Regressions</i>				<i>Regressions</i>			
PA → lagPA	0.376*	0.014	0.363	NA → lagNA	0.357*	0.014	0.351	LO → lagLO	0.348*	0.014	0.346
Vid →	-2.692*	0.327	-0.115	Vid →	3.548*	0.401	0.124	Vid →	0.033*	0.009	0.050
Restr.Times				Restr.Times				Restr.Times			
Vid → lagVid	0.288*	0.015	0.281	Vid → lagVid	0.287*	0.015	0.280	Vid ~ lagVid	0.289*	0.015	0.285
Restr.Times	0.079*	0.019	0.060	Restr.Times	0.075*	0.019	0.057	Restr.Times	0.081*	0.019	0.061
PA → lagVid	-0.702*	0.251	-0.039	NA → lagVid	1.146*	0.307	0.052	LO → lagVid	0.015*	0.007	0.029
Vid → lagPA	-0.002	0.001	-0.041	Vid → lagNA	0.002*	0.001	0.040	Vid → lagLO	0.039	0.029	0.019
<i>Covariances</i>				<i>Covariances</i>				<i>Covariances</i>			
PA ↔ Vid	-0.065	0.094	-0.011	NA ↔ Vid	0.165	0.115	0.022	LO ↔ Vid	-0.005*	0.003	-0.030
<i>Variances</i>				<i>Variances</i>				<i>Variances</i>			
PA	105.222*	2.265	0.840	NA	157.186*	3.383	0.841	LO	0.087*	0.002	0.872
Vid	0.364*	0.008	0.913	Vid	0.363*	0.008	0.912	Vid	0.364*	0.008	0.913
<i>Between Persons</i>											
<i>Covariances</i>				<i>Covariances</i>				<i>Covariances</i>			
PA ↔ Vid	0.928	1.195	0.081	NA ↔ Vid	0.801	1.397	0.081	LO ↔ Vid	-0.066	0.048	-0.143
<i>Variances</i>				<i>Variances</i>				<i>Variances</i>			
PA	277.246*	40.292	1.000	NA	375.379*	54.835	1.00	LO	0.450*	0.065	1.00
Vid	0.473*	0.071	1.000	Vid	0.474*	0.071	1.00	Vid	0.473*	0.071	1.000

Notes: SE = Standard Error; $p < .05$.

Table S5. Results from cross-lagged models examining reciprocal associations of telephone interactions with positive and negative affect and loneliness.

	Positive Affect			Negative Affect			Loneliness				
	Estimate	SE	Std.all	Estimate	SE	Std.all	Estimate	SE	Std.all		
<i>Within Persons</i>											
<i>Regressions</i>				<i>Regressions</i>				<i>Regressions</i>			
PA →lagPA	0.377*	0.014	0.363	NA →lagNA	0.359*	0.014	0.353	LO →lagLO	0.347*	0.014	0.345
Tel →	-2.775*	0.326	-0.119	Tel →	3.665*	0.401	0.128	Tel →	0.035*	0.009	0.054
Restr.Times				Restr.Times				Restr.Times			
Tel →lagTel	0.194*	0.015	0.191	Tel → lagTel	0.193*	0.015	0.191	Tel → lagTel	0.196*	0.015	0.190
Restr.Times	0.070*	0.024	0.044	Restr.Times	0.071*	0.024	0.045	Restr.Times	0.072*	0.023	0.046
PA →lagTel	0.171	0.208	0.011	NA →lagTel	-0.110	0.254	-0.006	LO →lagTel	-0.011	0.006	-0.027
Tel→lagPA	0.002	0.001	0.028	Tel →lagNA	-0.001	0.001	-0.025	Tel→lagLO	-0.108*	0.036	-0.045
<i>Covariances</i>				<i>Covariances</i>				<i>Covariances</i>			
PA ↔ Tel	-0.031	0.116	0.004	NA ↔ Tel	-0.262	0.141	-0.028	LO ↔ Tel	-0.004	0.003	-0.016
<i>Variances</i>				<i>Variances</i>				<i>Variances</i>			
PA	105.394*	2.268	0.842	NA	157.687*	3.394	0.844	LO	0.087*	0.002	0.873
Tel	0.547*	0.012	0.960	Tel	0.547*	0.012	0.960	Tel	0.547*	0.012	0.959
<i>Between Persons</i>											
<i>Covariances</i>				<i>Covariances</i>				<i>Covariances</i>			
PA ↔ Tel	3.031	1.591	0.200	NA ↔ Tel	-3.581	1.858	-0.204	LO ↔ Tel	-0.152*	0.065	-0.250
<i>Variances</i>				<i>Variances</i>				<i>Variances</i>			
PA	277.378*	40.313	1.000	NA	373.133*	54.798	1.000	LO	0.450*	0.065	1.000
Tel	0.825*	0.121	1.000	Tel	0.825*	0.112	1.000	Tel	0.824*	0.121	1.000

Notes: SE = Standard Error; $p < .05$.

Table S6. Results from cross-lagged models examining reciprocal associations of text-based digital interactions with positive and negative affect and loneliness

	Positive Affect			Negative Affect			Loneliness				
	Estimate	SE	Std.all	Estimate	SE	Std.all	Estimate	SE	Std.all		
<i>Within Persons</i>											
<i>Regressions</i>			<i>Regressions</i>			<i>Regressions</i>					
PA →lagPA	0.375*	0.014	0.362	NA →lagNA	0.358*	0.014	0.352	LO →lagLO	0.348*	0.014	0.346
Tbk →	-2.797*	0.327	-0.120	Tbk →	3.672*	0.402	0.129	Tbk →	0.035*	0.009	0.053
Restr.Times				Restr.Times				Restr.Times			
Tbk →lagTbk	0.200*	0.015	0.197	Tbk →lagTbk	0.201*	0.015	0.198	Tel→lagTel	0.200*	0.015	0.197
Restr.Times	0.070*	0.021	0.049	Restr.Times	0.066*	0.021	0.046	Restr.Times	0.071*	0.021	0.050
PA →lagTbk	0.449	0.230	0.027	NA →lagTbk	-0.181	0.282	-0.009	LO →lagTel	-0.002	0.007	-0.004
Tbk→lagPA	0.002	0.001	0.027	Tbk →lagNA	-0.000	0.001	-0.008	Tel→lagLO	-0.083*	0.032	-0.038
<i>Covariances</i>			<i>Covariances</i>			<i>Covariances</i>					
PA ↔ Tbk	0.306*	0.104	0.045	NA ↔ Tbk	-0.559*	0.128	-0.067	LO ↔ Tel	-0.010*	0.003	-0.053
<i>Variances</i>			<i>Variances</i>			<i>Variances</i>					
PA	105.316*	2.267	0.841	NA	157.674*	3.394	0.844	LO	0.087*	0.002	0.873
Tbk	0.446*	0.010	0.957	Tbk	0.446*	0.010	0.958	Tel	0.445*	0.010	0.956
<i>Between Persons</i>											
<i>Covariances</i>			<i>Covariances</i>			<i>Covariances</i>					
PA ↔ Tbk	5.471*	1.767	0.337	NA ↔ Tbk	-5.679*	2.042	-0.300	LO ↔ Tel	-0.331*	0.075	-0.505
<i>Variances</i>			<i>Variances</i>			<i>Variances</i>					
PA	277.721*	40.366	1.000	NA	375.756*	54.898	1.000	LO	0.451*	0.065	1.000
Tbk	0.951*	0.140	1.000	Tbk	0.952*	0.140	1.000	Tel	0.951*	0.139	1.000

Notes: SE = Standard Error; $p < .05$.

Manuscript II

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Study II: Social Interactions Buffer the Effects of Poor Health on Older Adults' Well-Being

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Data set and analysis code can be accessed at

https://osf.io/g3kaz/?view_only=3b402b4bef7745e0b3d88185584f862f

Abstract

This study examines whether social interactions in different modalities buffer the effects of poor self-reported health on well-being in older adults. We apply multilevel models to experience-sampling data including daily assessments of health, frequency of social interactions (face-to-face, telephone, digital text-based) and well-being (positive and negative affect, loneliness) from 118 older adults ($M_{\text{age}} = 71.75$; $SD_{\text{age}} = 5.05$). Between subjects, fewer health complaints were associated with higher well-being. Within-subjects, well-being was higher on days when subjects reported better health and fewer health complaints than their average. The findings regarding the buffering effects were inconsistent: In line with our hypothesis, on days with more face-to-face interactions, the effect of daily self-reported health on loneliness were smaller. Similarly, on days with more telephone interactions, the effects of daily self-reported health on positive affect and loneliness were smaller. Furthermore, for participants who experienced more telephone calls than others, the effect of overall health complaints on negative affect and loneliness were smaller. For participants who experienced more digital text-based social interactions than others, the effect of overall health complaints on positive affect and the effect of self-reported health on loneliness were weaker. Follow-up analyses that examined pleasantness of social interaction as a buffering factor show that pleasantness did not buffer adverse effects of poor health on well-being more consistently than the frequency of social interactions did. Taken together, our findings show that poor health is a risk factor for well-being and social interactions in different modalities might partially buffer those adverse effects.

Public Significance Statement

We examine whether social interactions in different modalities buffer the effects of poor health on well-being in older adults using experience-sampling data of 118 participants (average age = 71.75 years). Our findings from multilevel models suggest poor health as a risk factor for well-being and partially support the buffering hypothesis as we found that face-to-face, telephone and text-based digital interactions partly buffer this association.

Key words: buffering hypothesis, daily health, daily well-being, older adults, experience sampling

Theoretical Background

A higher frequency of social interaction is generally associated with better well-being (Grünjes et al., 2024; Lin & Lachmann, 2021; Teo et al., 2015), but more research is needed to understand the role of social interactions in different modalities for daily well-being in different contexts. In this study, we examine how health and social interactions in different modalities are related to well-being and whether social interactions in different modalities buffer the effects of poor health on well-being in older adults.

According to the buffering hypothesis of social support (Cohen & Wills, 1985), social support can protect individuals from harmful consequences of stressful events. Cohen and Wills (1985) define stress as a situation that the individual considers to be threatening and does not know how to cope with (Lazarus, 1966). According to Cohen and Wills (1985), buffering can occur in two ways: Either social support weakens the adverse effects of a stressor, or it prevents a stressor from significantly impairing the individual (see Figure 2 in Cohen & Wills, 1985). Perceiving one's health as poor or experiencing health complaints can be a stressful experience as declining health is associated with several negative outcomes such as impairments in daily life and loss of autonomy (Potter et al., 2022; Schöllgen et al., 2016). Cohen and Wills (1985) argue in their stress buffering hypothesis that social support can reduce negative outcomes of stress in two different ways: By offering and providing resources to help the individual handle the stressful situation, or by helping to reappraise it to help the individual regulate their response to the stressor. Social support can be provided in several different ways, including through social interactions (Lin & Lachman, 2024). However, evidence for the buffering effect of social support is less consistent if the stressors are related to a decline in health (Bhullar et al., 2010). It is especially important to examine associations between health and psychological well-being in old age as symptoms of psychological distress increasingly occur in comorbidity with physical decline and health problems as people grow older (Hussenoeder et al., 2021).

Several studies have shown that social support is beneficial for reducing the effects of stress on both physical health (Yang et al., 2016) and psychological outcomes (Gellert et al., 2018; Lin & Lachmann, 2021). In regard to psychological well-being, several studies have found that social support can buffer against a decline in well-being in old age (Bhullar et al., 2010; Gellert et al., 2018). Self-reported health plays an important role here as well: Schneider et al. (2004) found that subjective health reports show a higher correlation with experienced impairments in participants' daily lives rather than with problems that did not

impair their everyday life. Understanding whether and how social support can buffer negative consequences of declining health in an everyday context can help establish pathways on how older adults can be assisted to cope with physical decline and health problems.

The Frequency of Social Interactions as a Buffering Factor

In this current study, we conceptualize the frequency of daily social interactions in different modalities as a buffering factor. The frequency of social interaction is arguably related to both aspects of social support in the buffering hypothesis: Social interaction may increase perceived social support (amount of support that individuals think they can mobilize), as it reassures that someone is available (Helgeson, 1993). Social interaction can also lead to received social support, for example, if others offer advice and guidance (Helgeson, 1993). As social interactions can be carried out both in-person but also in multiple other ways including through digital communication channels, it is important to distinguish the different ways in which people interact with others. Haythornthwaite's (2001) media multiplexity theory suggests that every medium can facilitate strong interpersonal connections and that preexisting close ties may benefit from integrating new communication media use into the relationship. Similarly, Chan (2015) proposes that multimodal connectedness (number of technologies used for social interaction) can enhance well-being among older adults. With technology advancing and its use becoming more and more essential in everyday life, communication also shifts more and more from face-to-face interactions to digitally mediated interactions such as emails and text-messages: The proportion of older adults using the internet and digital interaction tools increases rapidly (Hunsaker & Hargittai, 2018; König et al., 2018). Moreover, instrumental support (e.g. from medical services) increasingly takes place via digital tools (Mace et al., 2022). Even though those digital advances can come with challenges (Seifert, 2023), the availability of social interactions increases with the use of digital communication, which may increase the amount of perceived and received social support. Being digitally connected to others can increase the perception of social connectedness and can therefore be useful to improve well-being (Heo et al., 2015). Further, it may allow for individuals to interact with close others that are not physically close during times of stress and can only be reached through digital means (Jung et al., 2017).

Frequent social interactions are associated with higher well-being (Lin & Lachmann, 2021; Skalačka & Pajestka, 2021), both immediately (Bernstein et al., 2018) and over the long-term (Teo et al., 2015). Even though research suggests that the frequency of face-to-face interaction is uniquely associated with well-being across the lifespan and predict well-being

more consistently than other modalities (Sun et al., 2020), there is growing evidence that technology-mediated interactions are also related to higher well-being in older adults (Grünjes et al., 2024; Kim & Fingerman, 2022; Lee et al., 2022). Poor health may lead to limited access to social life as it can come with functional limitations. Digital communication could be an essential factor to make staying in touch and receiving social support more accessible for those people who report poorer health in general or on days when health is perceived as poorer than usual.

Further, declining network sizes in older age (English & Carstensen, 2014) pose the threat of isolation and loneliness for older adults. Connecting with others in multiple, easily accessible ways could be a new way of receiving social support. Increased use of social media and digital communication tools hold the possibility to compensate for age-related decreases in network size (Kim & Fingerman, 2022) which can influence perceptions of available social support. Digital interaction modalities have also shown compensating effects for decreasing face-to-face contact (Grünjes et al., 2024). Although younger people tend to use smartphones and social media more often than older adults, most older adults in industrialized countries own and use a smartphone on a daily basis (Gaia et al., 2020). Jung et al. (2017) asked older adults (Mage = 80.4 years, range = 65-95 years) in in-depth interviews for their reasons for using Facebook and the wish to stay connected to others, especially those who became less accessible due to poorer health, was the most common answer.

This Study

The present study aims at examining potential buffering effects of social interactions in different modalities on the association between daily variations in health and well-being. We conceptualize self-reported (poor) health as a daily stressor. The literature on stress buffering is less consistent for health-related stressors compared with other types of stressors (Hussenoeder et al., 2021). Previous research shows that daily variations in self-reported health and self-reported health complaints are related to daily well-being at the within-person level (Potter et al., 2022). For example, Potter et al. (2022) found that more daily health symptoms were associated with below-average reports of positive affect and above-average reports of negative affect at the within-person level. We chose to focus on three aspects of psychological well-being as outcomes, including positive and negative affect and loneliness to achieve a rich operationalization of well-being. We chose those three aspect in particular as they have shown associations with frequency of social interactions in daily life (e.g. Hall et al., 2022; Lin & Lachmann, 2021) and vary on a daily basis (Awad et al., 2023; Buecker et al.,

2024; Röcke et al., 2009; Van Roekel et al., 2014). We conceptualize the frequency of social interactions in different modalities as a buffering factor, because previous research has shown positive associations between frequency of social interactions and daily well-being and that there are differences in the association between daily well-being and different interaction modalities (e.g. Lin & Lachman, 2024; Skałacka & Pajestka, 2021). Therefore, we expect frequency of social interactions to be able to show buffering effects as well.

Hypotheses

Based on the buffering hypothesis of social support (Cohen & Wills, 1985) and given that health constraints are negatively associated (Bhullar et al., 2010; Potter et al., 2022; Yang et al., 2016), whereas social interactions are positively associated with well-being (Lin & Lachman, 2024; Skałacka & Pajestka, 2021), it is plausible to assume that engaging in frequent social interactions can buffer negative consequences of health on well-being. Older adults use digitally mediated communication tools at an increasing rate, thus it is of interest to investigate how communication channels that are not in-person (e.g. telephone calls or digital text-based interactions) can be utilized to maintain and increase well-being in old age. Further, research has shown that daily variations in health assessment are associated with daily variations in well-being both at the between- and the within-person level (Potter et al., 2022; Schöllgen et al., 2016) which makes considering both between-person and within person differences crucial.

This study focusses on the main effects of self-reported health on well-being and loneliness as well as on the main effects of social interaction frequency in different modalities on daily well-being and loneliness. Further, it tests possible buffering effects of higher frequencies of social interactions on the association between poor health and well-being by examining interaction effects of poor self-reported health and social interaction frequency on well-being and loneliness.

We hypothesize that self-reported health complaints can be considered daily stressors that are related to lower daily well-being. We expect that participants who report lower levels of self-reported health and more health complaints will report lower well-being than participants who report better self-reported health and fewer health complaints (between person). Further, we expect that on days when participants report lower self-reported health and more health complaints than usual, they will also report lower levels of well-being than usual (within-person). We hypothesize that the number of daily interactions will buffer negative effects of health complaints and poor self-reported health on well-being. For

participants who report more social interactions than others, we expect that the effect of poor self-reported health and more health complaints on well-being will be weaker compared with participants who report fewer social interactions (buffering effect, between-person).

Furthermore, on days when participants report more social interactions than usual, we expect poor self-reported health and more health complaints to show weaker associations with well-being compared with days with fewer social interactions than usual (buffering effect, within person). We hypothesize that frequency of face-to-face interaction will buffer negative consequences of poor self-reported health and self-reported health complaints more consistently than the frequency of telephone and text-based digital interactions.

Methods

Detailed descriptions of participants, procedures, and measures can be found in earlier publications (Macdonald & Hülür, 2020). Select details relevant to the present study are given below.

Transparency and Openness

The study procedures were reviewed and approved by the Ethics Committee of the Faculty of Arts and Social Sciences at the University of Zurich (Nr. 19.2.17) under the title “Communication and Interaction in Old Age.”. The hypotheses and analytic plan were not preregistered. The data set and analysis code can be accessed online here:

https://osf.io/g3kaz/?view_only=3b402b4bef7745e0b3d88185584f862f (Grünjes et al., 2025).

Data were analyzed using the lme4 package (Bates et al., 2015) in R Studio (R Core Team, 2018). This study is based on a secondary data analysis and the data collection was not designed to address the research questions of the present study. Previous work based on the same data set examined the associations of social interactions, interaction modality, time spent interacting, time spent alone, and interaction purpose with daily well-being and/or social interaction quality (Hülür et al., 2023; Luo, Macdonald, et al., 2022; Luo, Pauly, et al., 2022; Macdonald et al., 2021). Further, a subsample of the participants was reassessed during the COVID-19 pandemic to examine changes in well-being during this time period (Grünjes et al., 2024; Macdonald & Hülür, 2021).

Participants and Procedure

We use data from 118 older adults ($M_{\text{age}} = 71.75$; $SD_{\text{age}} = 5.05$; $\text{range}_{\text{age}} = 65\text{--}94$ years; 47 identified as female, 71 identified as male) from German-speaking regions of Switzerland (Macdonald & Hülür, 2020). Forty-nine of our participants were living alone (40%), 68% of participants were retired and not working. Participants were recruited via local and national

newspapers and through a database of participants hosted at the University of Zurich in Switzerland. Inclusion criteria were being fluent in German, being at least 65 years old or older, sufficient hearing and vision, and the use of digital devices for communication. We excluded two from the originally 120 participants: One participant misunderstood the instructions and reported only digital interactions, and one participant dropped out of the study voluntarily. Experience sampling data were collected daily over the course of 3 weeks between April and November 2019. Before participating in the 21-day daily diary study, eligible participants took part in a baseline session at the University of Zurich, where they were informed about the study procedures and received an iPhone 4S on which they completed the daily diary assessment. Participants started the daily diary assessment of social interactions and well-being the day after the baseline session. During these 21 days, participants were asked to record any social interactions that lasted longer than 5 min during that day and took place either in a spoken way (face-to-face or telephone interaction) or text-based (email or SMS). Every evening, participants were asked to complete an assessment that included measurements of positive and negative affect and loneliness. In total, that gave us up to 21 daily questionnaires per participant, one for each day in 3 weeks. On average, participants answered 19 out of 21 daily questionnaires ($SD = 2.78$).

Measures

Descriptive statistics and correlations of study variables are reported in Table 1.

Table 1. Means, standard deviations, and correlations with confidence intervals.

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9
1. Age	71.73	5.05									
2. Gender	0.60	0.49	.04								
			[-.00, .08]								
3. Positive Affect	69.83	15.95	-.11*	-.06*							
			[-.16, -.07]	[-.10, -.02]							
4. Negative Affect	13.89	14.35	.07*	.04*	-.45*						
			[.03, .11]	[.00, .08]	[-.48, -.42]						
5. Loneliness	18.74	17.49	.20*	.01	-.58*	.66*					
			[.16, .24]	[-.04, .05]	[-.61, -.55]	[.63, .68]					
6. Daily Face-to-Face Interactions	1.77	1.65	-.14*	.08*	.20*	-.06*	-.17*				
			[-.18, -.10]	[.03, .12]	[.16, .24]	[-.10, -.02]	[-.21, -.13]				
7. Daily Telephone Interactions	0.52	0.92	-.05*	-.19*	-.04*	.02	-.01	-.03			
			[-.10, -.01]	[-.23, -.15]	[-.09, -.00]	[-.02, .06]	[-.06, .03]	[-.07, .01]			
8. Daily Digital Interactions	1.27	2.80	-.08*	-.02	.04	-.13*	-.09*	-.04	.10*		
			[-.12, -.04]	[-.06, .02]	[-.00, .08]	[-.17, -.09]	[-.13, -.05]	[-.08, .01]	[.06, .15]		
9. Self-reported Health	80.19	21.41	-.11*	.01	.53*	-.42*	-.43*	.10*	-.00	.07*	
			[-.15, -.07]	[-.03, .05]	[.50, .56]	[-.45, -.38]	[-.46, -.39]	[.05, .14]	[-.04, .04]	[.03, .11]	
10. Health complaints	0.19	0.39	.11*	-.08*	-.17*	.12*	.13*	-.00	-.05*	-.01	-.57*
			[.07, .15]	[-.12, -.04]	[-.21, -.13]	[.08, .16]	[.09, .17]	[-.04, .04]	[-.09, -.01]	[-.05, .03]	[-.59, -.54]

Note. *M* = mean, *SD* = standard deviation. Values in square brackets indicate the 95% confidence interval for each correlation.

* indicates $p < .05$.

Outcomes. Outcome variables were positive and negative affect and loneliness measured daily for 21 consecutive days. Positive and negative affect was measured using 20 adjectives in total, with 10 adjectives for positive affect and 10 adjectives for negative affect that were taken from the German version (Breyer & Bluemke, 2016) of the Positive and Negative Affect Schedule (PANAS, Watson et al., 1988). Participants were asked to indicate how they felt during each day using a slider scale ranging from “not at all” to “very much” (0-100). Adjectives for positive affect ($M = 69.83$, $SD = 11.59$) included active, interested, excited, strong, inspired, proud, enthusiastic, alert, determined, and attentive, with higher values indicating more positive affect. Adjectives for negative affect ($M = 14.03$; $SD = 11.17$) included distressed, upset, guilty, scared, hostile, irritable, ashamed, nervous, and afraid, and jittery, with higher values indicating more negative affect. Participants were also asked to indicate their loneliness using five adjectives (lonely, belonging [reverse coded], alone, accepted [reverse coded], isolated) developed by the authors (Macdonald & Hülür, 2020; $M = 18.82$; $SD = 13.36$), with higher values indicating higher loneliness. Reliability estimates were high for all outcomes: (positive affect: $\omega_{\text{within}} = .90$, $\omega_{\text{between}} = .92$; negative affect: $\omega_{\text{within}} = .84$, $\omega_{\text{between}} > .95$; loneliness: $\omega_{\text{within}} = .82$; $\omega_{\text{between}} = .94$).

Predictors. We defined poor health as stressor that is related to daily fluctuations of well-being. We measured daily self-reported health (“how healthy do you feel today?”) on a slider scale ranging from “not at all” to “very much” (0-100; $M = 79.79$, $SD = 15.89$, range = 36.59_ – 100) and self-reported health complaints (“Have you had any health problems today?”) dichotomously (0 = no; 1 = yes). A health complaint was reported on 20% of all observations. A higher value in the first variable indicates better health whereas a higher value in the second variable indicates poorer health. The variables were separated into time-invariant and time varying components (Bolger & Laurenceau, 2013). The between-person component was calculated as the average across an individual’s time series, indicating the average self-reported health and the proportion of days with self-reported health complaints over the study period of 21 days. The within-person components indicated daily deviations from the individual’s average, with 0 indicating each individual’s average response. The between person component was centered around the sample mean.

Moderator variables. Daily interaction frequency per modality was indicated by the frequency of face-to-face interactions, telephone interactions, and text-based digital interactions during the day. Whenever an interaction took place, participants reported how, with whom, and how long they interacted. Based on these reports, we calculated the number

of social interactions per modality per day. In general, participants reported to have most interactions face-to-face (with the between-person mean being $M = 1.76$, $SD = 1.17$), followed by text-based digital interactions ($M = 1.22$; $SD = 2.24$), whereas participants used the telephone relatively less to interact with others ($M = 0.51$; $SD = 0.55$). As with the health variables, the social interaction frequency variables were also separated into time-variant and time-varying components. The between-person component indicated the average frequency of communication via a given modality over the study period and was centered around the sample mean. The within-person component indicated daily deviations from the individual's average, with each individual's average social interaction frequency being indicated by 0.

Control variables. Control variables included participants' age in years ($M = 71.75$, $SD = 5.05$) and gender (0 = women, 1 = men; 60,2% men). The control variables were centered at sample means.

Analysis

Data were analyzed using multilevel models based on up to 21 occasions of data per participant to examine associations of daily well-being (positive and negative affect and loneliness) with daily self-reported health (complaint) moderated by the frequency of communication via different interaction modalities (face-to-face, telephone calls, text-based digital communication). We examined origins of variability in terms of intraclass correlations for positive affect (51% at the day level and 49% at the person level), negative affect (58% at the day level and 42% at the person level) and loneliness (61% at the day level and 39% person level), for social interactions in different modalities: face-to-face interactions (31% at the day level and 69% at the person level), telephone interactions (26% at the day level and 74% at the person level) and digital text-based interactions (51% at the day level and 49% at the person level), and for self-reported health (51% at the day level and 49% at the person level) and health complaints (40% at the day level and 60% at the person level). Models were estimated in R (R Core Team, 2018) using the lme4 package (Bates et al., 2015). The buffering effects were defined as moderating effects of the daily frequency of use of an interaction modality on the association between daily self-reported health and daily well-being. At the within-person (WP) level, the models were specified as:

$$\text{Outcome}_{ti} = \beta_{0i} + \beta_{1i} (\text{frequency of face-to-face interactions WP}_{ti}) + \beta_{2i} (\text{self-reported health WP}_{ti}) + \beta_{3i} (\text{frequency of face-to-face interactions WP}_{ti} \times \text{self-reported health WP}_{ti}) + e_{ti} \quad (1)$$

where $Outcome_{it}$, the person i 's score for positive affect, negative affect, or loneliness that day t , is a function of β_{0i} , an individual-specific intercept parameter and β_{1i} , which captures the effect of the daily frequency of social interactions in one of the three modalities (face-to-face, telephone, digital text-based) and β_{2i} , which captures the effect of daily self-reported health or daily health complaints. β_{3i} captures the interaction between these two variables on the association with the $Outcome_{it}$, i.e., the within-person buffering effect. e_{it} represents residual error.

At the between-person level (BP), individual-specific parameters were modeled as:

$$\beta_{0i} = \gamma_{00} + \gamma_{01} (\text{frequency of social interactions BP}_i) + \gamma_{02} (\text{self-reported health BP}_i) + \gamma_{03} (\text{frequency of social interactions BP}_i \times \text{self-reported health BP}_i) + \mu_{0i} \quad (2)$$

$$\beta_{1i} = \gamma_{10} \quad (3)$$

$$\beta_{2i} = \gamma_{20} \quad (4)$$

$$\beta_{3i} = \gamma_{30} \quad (5)$$

where γ_{00} represents the average of outcome variables (positive affect, negative affect, loneliness) across all individuals. γ_{01} indicates the between-person association between the average number of social interactions in one modality over 21 days and the outcome variable and γ_{02} indicated the between-person association between the average self-reported health over 21 days and the outcome variable. γ_{03} indicated the interaction effect of average social interaction frequency and average self-reported health on the outcomes, i.e., the between person buffering effect. γ_{10} represents the sample-level association between the daily number of social interactions in one modality relative to one's own average and the outcome variable and γ_{20} represents the sample-level association between the daily self-reported health relative to one's own average and the outcome variable. γ_{30} represents the sample-average within person buffering effect. μ_{0i} represents individual-specific deviations.

Results

Associations between Health and Well-Being

First, we tested the hypothesis that poor health is related to lower daily well-being using multilevel models with either self-reported health or self-reported health complaints as predictor and positive affect, negative affect or loneliness as outcome. Results are shown in Table 2.

Self-reported health was significantly associated with well-being. Participants who reported better daily health than other participants reported more positive affect ($\gamma = 0.43$, $CI = 0.32 - 0.53$, $p < .001$), less negative affect ($\gamma = -0.39$, $CI = -0.50 - -0.28$, $p < .001$) and less loneliness ($\gamma = -0.46$, $CI = -0.59 - -0.33$, $p < .001$) than participants who reported worse health. On days when participants felt healthier than usual, they reported more positive affect ($\gamma = 0.35$, $CI = 0.32 - 0.38$, $p < .001$), less negative affect ($\gamma = -0.14$, $CI = -0.17 - -0.12$, $p < .001$), and less loneliness ($\gamma = -0.21$, $CI = -0.25 - -0.18$, $p < .001$) than on days when they felt less healthy. For self-reported health complaints, significant associations were only found at the within-person level: on days when participants reported health complaints, they reported less positive affect ($\gamma = -7.55$, $CI = -9.08 - -6.03$, $p < .001$), more negative affect ($\gamma = 1.75$, $CI = 0.45 - 3.05$, $p = .008$) and more loneliness ($\gamma = 3.74$, $CI = 2.14 - 5.33$, $p < .001$) than on days with no self-reported health complaints. At the between-person level, the proportion of days with health complaints over the course of the study was unrelated to between-person differences in well-being. Results remained the same when we controlled for participants' age and gender.

Table 2. Results from models examining the effects of self-reported health and health complaints on positive and negative affect and loneliness.




	Positive Affect			Negative Affect			Loneliness		
	Estimate	SE	p	Estimate	SE	p	Estimate	SE	p
Fixed effects									
<i>How healthy do you feel today?</i>									
Intercept (γ_{00})	69.78*	0.88	<.001	14.01*	0.86	<.001	18.81*	1.04	<.001
Between-Person (γ_{01})	0.43*	0.06	<.001	-0.39*	0.06	<.001	-0.46*	0.07	<.001
Within-Person (γ_{10})	0.35*	0.01	<.001	-0.15*	0.01	<.001	-0.21*	0.02	<.001
<i>Do you have any health complaints today?</i>									
Intercept (γ_{00})	69.80*	1.07	<.001	14.00*	1.02	<.001	18.79*	1.22	<.001
Between-Person (γ_{01})	-5.74	4.10	.165	7.60	3.92	.055	8.41	4.71	.077
Within-Person (γ_{01})	-7.55*	0.78	<.001	1.75*	0.66	.008	3.74*	0.81	<.001

Notes: Number of observations = 2224, N = 118; γ = Estimate; SE = Standard Error; * $p < .05$.
Random intercepts and residual variances were estimated, but not included in this table.

Buffering Effects of Social Interaction Frequency and Modality of Health on Well-Being

Buffering effects were indicated by moderating effects of social interaction frequency (in different modalities) on the association between self-reported health (complaints) and well-being. Figure 1 gives an overview of all the buffering effects we found. More details on the buffering effects are provided in the tables below. Buffering effects on self-reported health can be found in table 3, whereas table 4 shows the buffering effects on self-reported health complaints.

Figure 1. Overview of buffering effects.

		self-reported health			self-reported health complaint		
Frequency of social interaction		Positive Affect	Negative Affect	Loneliness	Positive Affect	Negative Affect	Loneliness
	between-person	⊗	⊗	⊗	⊗	⊗	⊗
	within-person	⊗	!	☑	⊗	⊗	⊗
	between-person	⊗	⊗	⊗	⊗	☑	☑
	within-person	☑	⊗	☑	⊗	⊗	⊗
	between-person	⊗	⊗	☑	☑	⊗	⊗
	within-person	⊗	⊗	⊗	⊗	⊗	⊗

Notes: A checkmark indicates a significant interaction that confirms our hypothesis, a cross indicates no significant interaction, the exclamation point marks a significant interaction that goes against our hypothesis.

Table 3. Results from models examining the effects of self-reported daily health, face-to-face, telephone, and text-based digital interactions on positive and negative affect and loneliness as well as moderating effects of interaction modality on the effects of self-reported daily health on well-being (interaction effects).

	Positive Affect			Negative Affect			Loneliness		
	Estimate	SE	p	Estimate	SE	p	Estimate	SE	p
Fixed Effects									
<i>Face-to-Face Social Interactions</i>									
Intercept	69.72*	0.86	<.001	13.87*	0.88	<.001	13.87*	0.88	<.001
F2F (between-person)	2.16*	0.75	.005	-0.24	0.76	.753	-1.97*	0.91	.032
F2F (within-person)	0.74*	0.18	<.001	-0.16	0.17	.338	-1.03*	0.02	<.001
Health today (between-person)	0.42*	0.06	<.001	-0.37*	0.06	<.001	-0.42*	0.07	<.001
Health today (within-person)	0.34*	0.02	<.001	-0.14*	0.01	<.001	-0.20*	0.02	<.001
F2F X Health Today (between-person)	0.04	0.06	.452	0.05	0.06	.382	0.07	0.07	.294
F2F X Health Today (within-person)	-0.02	0.01	.154	0.02*	0.01	.049	0.04*	0.01	.001
<i>Telephone Social Interactions</i>									
Intercept	69.76*	0.88	<.001	14.01*	0.86	<.001	18.80*	1.05	<.001
Telephone (between-person)	-1.72	1.59	.281	0.62	1.58	.696	-0.37	1.91	.849
Telephone (within-person)	-0.07	0.29	.817	0.24	0.27	.359	-0.01	0.32	.973
Health today (between-person)	0.43*	0.06	<.001	-0.39*	0.06	<.001	-0.45*	0.07	<.001
Health today (within-person)	0.35*	0.01	<.001	-0.14*	0.01	<.001	0.21*	0.01	<.001
Tel X Health Today (between-person)	0.08	0.12	.499	0.01	0.12	.931	0.10	0.15	.505

Tel X Health Today (within-person)	-0.08*	0.02	.001	0.01	0.02	.430	0.07*	0.03	.014
	<i>Digital Social Interactions</i>								
Intercept	69.96*	0.91	<.001	13.58*	0.87	<.001	18.19*	1.06	<.001
Digital (between-person)	0.40	0.60	.506	-1.49*	0.58	.011	-1.71*	0.70	.016
Digital (within-person)	-0.13	0.13	.310	0.00	0.12	.983	0.04	0.15	.769
Health today (between-person)	0.41*	0.06	.011	-0.34*	0.06	<.001	-0.39*	0.07	<.001
Healthy today (within-person)	0.35*	0.01	<.001	-0.15*	0.01	<.001	-0.21*	0.02	<.001
Dig X Health Today (between-person)	-0.04	0.05	.415	0.09	0.05	.051	0.14*	0.06	.021
Dig X Health Today (within-person)	-0.01	0.01	.179	-0.00	0.01	.952	0.01	0.01	.561

Notes: Number of observations = 2224, N = 118; γ = Estimate; SE = Standard Error; * $p < .05$.
 Random intercepts and residual variances were estimated, but not included in this table.

Table 4. Results from models examining the effects of health complaints, face-to-face, telephone, and text-based digital interactions on positive and negative affect and loneliness as well as moderating effects of interaction modality on the effects of health complaints on well-being (interaction effects).

	Positive Affect			Negative Affect			Loneliness		
	γ	SE	p	γ	SE	p	γ	SE	p
Fixed Effects									
<i>Face-to-Face Social Interactions</i>									
Intercept	69.80*	1.03	<.001	14.03*	1.02	<.001	18.85*	1.19	<.001
F2F (between-person)	3.02*	0.90	.001	-0.91	0.89	.312	-2.88*	1.04	.006
F2F (within-person)	0.97*	0.20	<.001	-0.26	0.17	.131	-1.14*	0.21	<.001
Health Complaint (between-person)	-6.09	3.97	.127	7.55	3.95	.058	8.29	4.58	.073
Health Complaint (within-person)	.730*	0.78	<.001	1.71*	0.67	.011	3.35*	0.81	<.001
F2F X Health Complaint (between-person)	2.36	4.28	.582	-2.95	4.26	.490	-9.10	4.94	.068
F2F X Health Complaint (within-person)	0.66	0.70	.345	0.02	0.60	.968	-1.43	0.73	.0503
<i>Telephone Social Interactions</i>									
Intercept	69.88*	1.11	<.001	13.42*	1.04	<.001	18.03*	1.25	<.001
Telephone (between-person)	-1.82	2.07	.381	-0.43	1.95	.826	-1.97	2.34	.400
Telephone (within-person)	-0.15	0.32	.650	0.28	0.27	.301	0.05	0.34	.891
Health Complaint (between-person)	-5.83	4.68	.215	3.75	4.41	.396	2.84	5.27	.592
Health Complaint (within-person)	-7.51*	0.78	<.001	1.72*	0.66	.010	3.70*	0.81	<.001

Tel X Health Complaint (between-person)	3.93	14.09	.781	-27.49*	13.26	.040	-36.72*	15.88	.023
Tel X Health Complaint (within-person)	1.80	1.20	.134	-1.12	1.02	.272	-2.05	1.26	.102
<i>Digital Social Interactions</i>									
Intercept	69.89*	1.04	<.001	13.97*	1.00	<.001	18.73*	1.21	<.001
Digital (between-person)	0.98	0.50	.054	-1.18*	0.49	.017	-1.28*	0.59	.031
Digital (within-person)	-0.14	0.15	.319	0.02	0.12	.873	0.07	0.15	.667
Health Complaint (between- person)	-4.91	3.99	.221	7.09	3.87	.069	7.67	4.65	.102
Health Complaint (within- person)	-7.54*	0.78	<.001	1.75	0.66	.873	3.75*	0.15	<.001
Dig X Health Complaint (between-person)	5.98*	2.07	.005	-2.28	2.00	.257	-4.27	2.41	.079
Dig X Health Complaint (within-person)	-0.35	0.59	.557	0.13	0.50	.805	-0.41	0.61	.503

Notes: Number of observations = 2224, N = 118; γ = Estimate; SE = Standard Error; * $p < .05$.

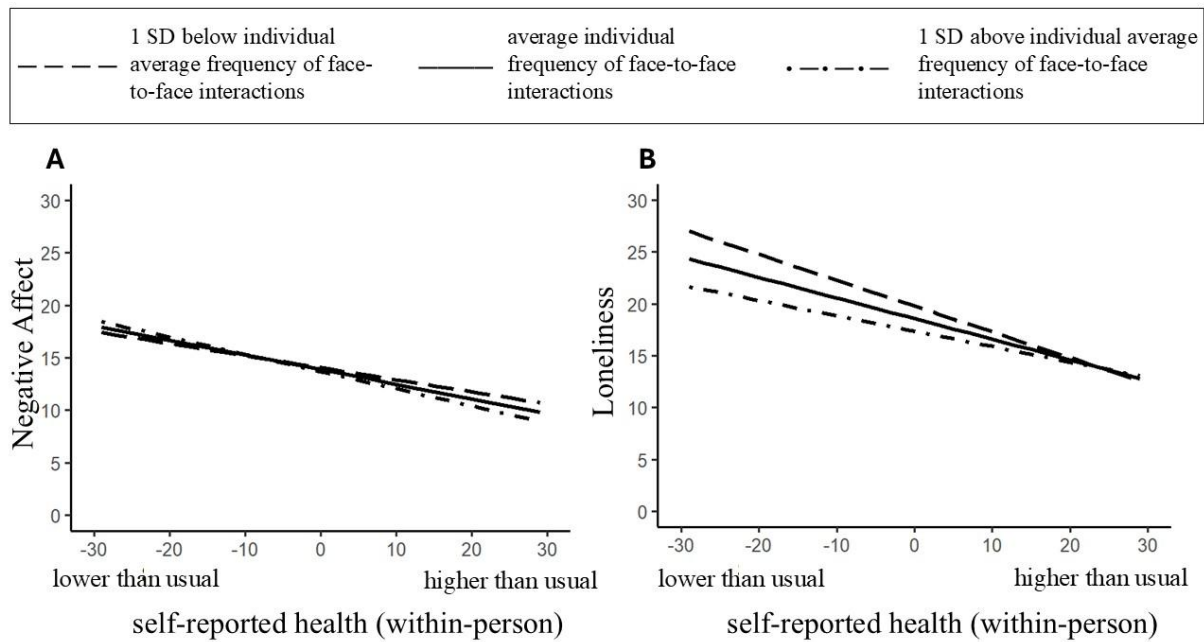
Random intercepts and residual variances were estimated, but not included in this table

Face-to-face interactions. Regarding the main effects of face-to-face interactions and well-being, participants with more face-to-face interactions over 21 days reported higher positive affect ($\gamma = 2.16$, CI = 0.69 – 3.62, $p = .004$) and less loneliness ($\gamma = -1.97$, CI = -3.76 – -0.19, $p = .030$) than participants with fewer face-to-face interactions over the course of three weeks. On days when participants reported more face-to-face interactions than usual they also reported higher positive affect ($\gamma = 0.74$, CI = 0.39 – 1.09, $p > .001$) and less loneliness ($\gamma = 1.03$, CI = -1.42 – -0.64, $p < .001$). The frequency of face-to-face interactions was not related to negative affect at the between- or within-person level.

There were no significant interaction effects for face-to-face interactions and self-reported health on positive affect. However, there were significant interactions for frequency of face-to-face interactions and self-reported health at the within-person level on negative affect ($\gamma = 0.02$, CI = 0.00 – 0.04, $p = .049$) and loneliness ($\gamma = 0.04$, CI = 0.02 – 0.07, $p = .001$). These effects are illustrated in Figure 2 (Panel A: negative affect; Panel B: loneliness). For negative affect, we found the opposite of buffering: Our findings showed that the frequency of face-to-face interactions mattered more for lower negative affect on days with good health vs. on days with poor health. When participants reported better health than usual they reported even less negative affect when they also reported more face-to-face interactions than usual compared to days on which they reported fewer face-to-face interactions than usual. Participants also reported more negative affect on days when they reported not only worse health than usual but also fewer face-to-face interactions than usual. These findings suggests that social interactions may be more beneficial for lower negative affect on days with better health, and is this inconsistent with a buffering interpretation. On days, when participants reported worse health than usual, they reported more loneliness when they also reported fewer face-to-face interactions than usual compared to when they reported more face-to-face interactions than usual. This indicates that higher frequency of face-to-face interactions can buffer negative effects of worse self-reported health on loneliness. That is, the frequency of face-to-face social interactions mattered more for loneliness on days with poor health.

We found no significant interaction effects that would indicate that the frequency of face-to-face interactions buffered negative effects from self-reported health complaints on well-being.

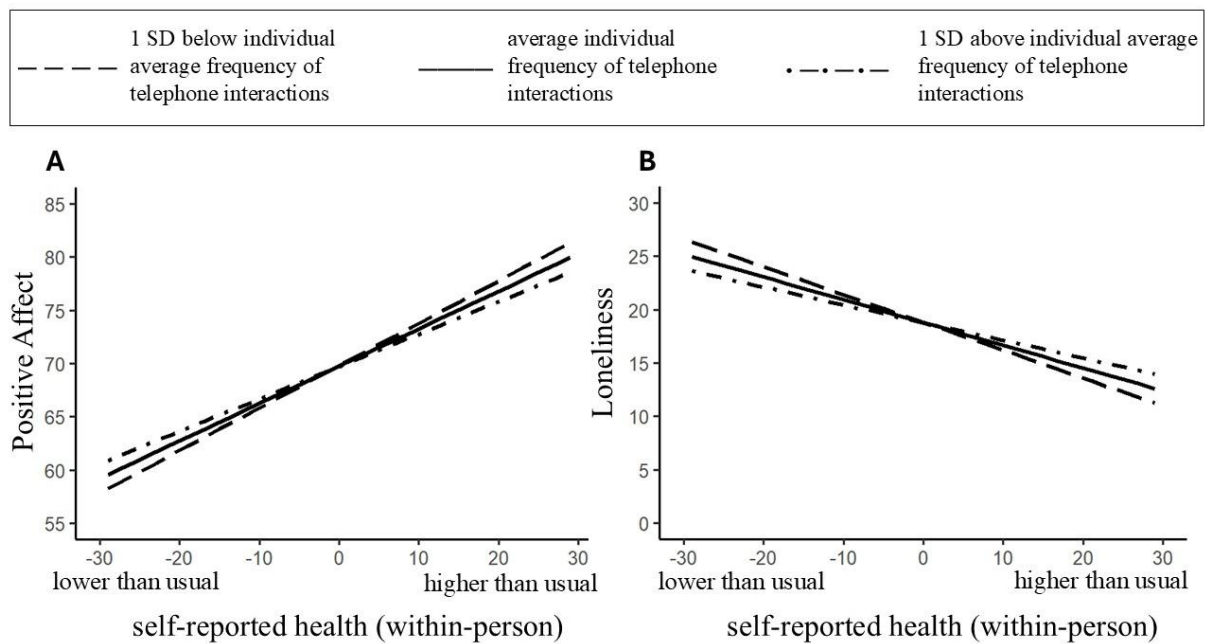
Figure 2. Significant interaction effects of face-to-face interactions at the within-person level.



Notes: Below/above individual average indicates 1 SD deviation of the individual's own average of frequency of face-to-face interactions across the study period of 21 days. The outcome variables range from 0 to 100. The y-axis of the plot is adjusted to enhance readability, which may make differences appear larger than they are within the full potential range.

Telephone interactions. There were no significant effects of frequency of telephone interactions on positive and negative affect and loneliness, neither at between- nor within person level. However, there were significant interaction effects of frequency of telephone use and self-reported health at the within-person level on positive affect ($\gamma = -0.08$, CI = -0.013 – -0.04, $p = .001$) and on loneliness ($\gamma = 0.07$, CI = 0.01 – 0.12, $p = .014$) supporting our hypothesis. These effects are illustrated in Figure 3 (Panel A: positive affect, Panel B: loneliness). Results indicate that on days when participants reported poorer health and fewer telephone calls than usual, they also reported less positive affect and more loneliness compared to when they reported a higher frequency of telephone interactions than usual on days with poorer health. Thus, a higher than usual frequency of telephone interactions weakens the association between poor health and lower well-being.

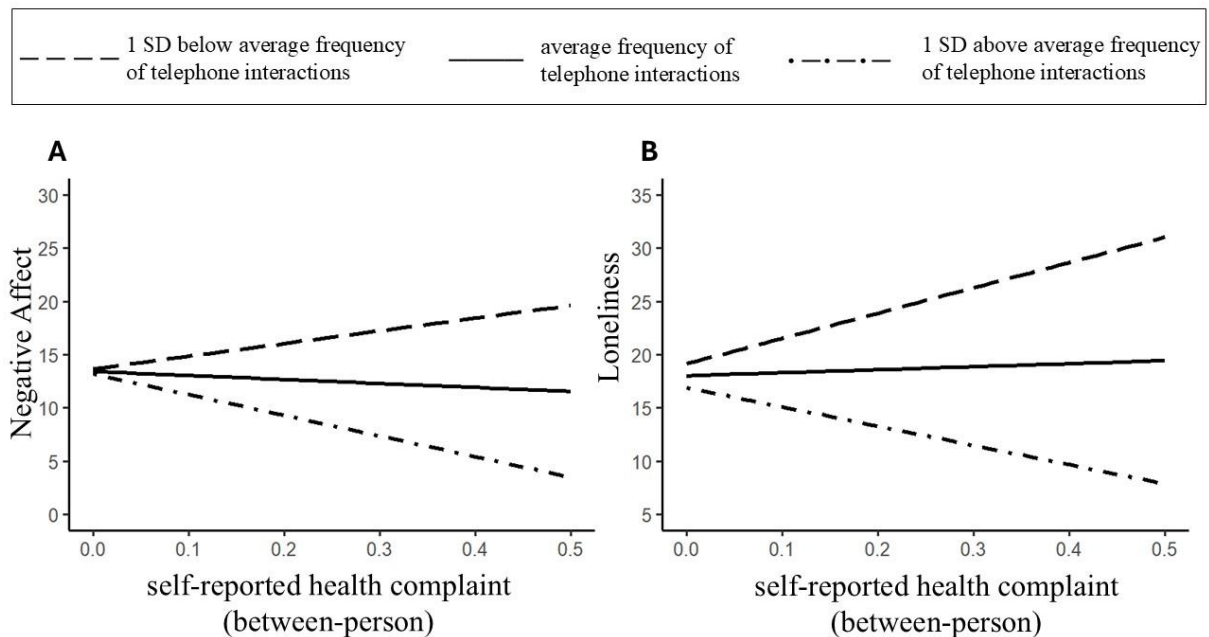
Figure 3. Significant interaction effects of telephone interactions at the within-person level.



Notes: Below/above individual average indicates 1 SD deviation of the individual's own average of frequency of face-to-face interactions across the study period of 21 days. The outcome variables range from 0 to 100. The y-axis of the plot is adjusted to enhance readability, which may make differences appear larger than they are within the full potential range.

There were also significant interaction effects at the between-person level for the frequency of telephone calls and health complaints on negative affect ($\gamma = -27.487$, $CI = 53.49 - -1.48$, $p = .038$) and on loneliness ($\gamma = -36.73$, $CI = -67.86 - -5.59$, $p = .021$). These results are illustrated in Figure 4. They indicate that participants who report a higher frequency of telephone interactions and more health complaints report less negative affect and less loneliness than participants who also report more health complaints but fewer telephone interactions. This indicates that higher frequency of telephone interactions can buffer negative effects of health complaints on negative affect and on loneliness.

Figure 4. Significant interaction effects of telephone interactions at the between-person level.



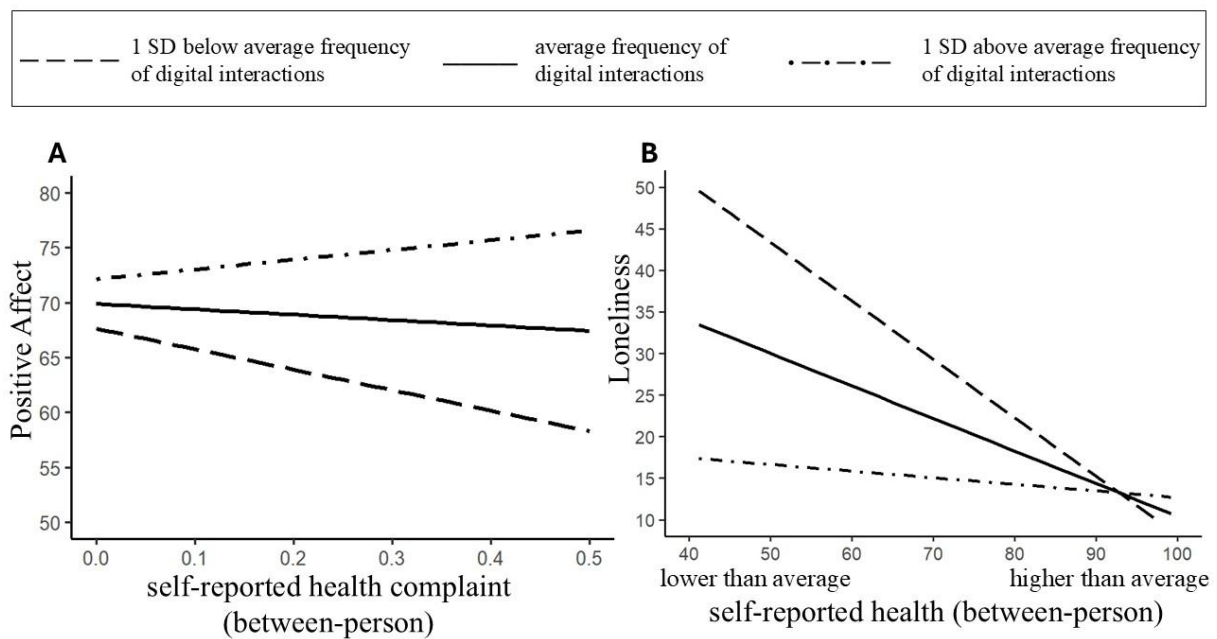
Notes: Below/above average frequency of telephone interaction indicates 1 SD deviation from the sample average of telephone interactions across the study period of 21 days. The outcome variables range from 0 to 100. The y-axis of the plot is adjusted to enhance readability, which may make differences appear larger than they are within the full potential range.

Text-based digital interactions. There were no significant effects of frequency of text-based digital interactions on positive affect. There was a significant effect of frequency of text-based digital interaction on negative affect ($\gamma = -1.49$, CI = $-2.62 - -0.36$, $p = .010$) and loneliness ($\gamma = -1.71$, CI = $-3.08 - -0.34$, $p = .014$) at the between-person level indicating that participants who reported a higher frequency of interactions in this modality also reported lower levels of negative affect and loneliness.

There were significant interaction effects on positive affect ($\gamma = 0.09$, CI = $-0.02 - 0.02$, $p = .016$) and loneliness ($\gamma = 0.14$, CI = $0.02 - 0.25$, $p = .020$) for the frequency of text based digital interactions and self-reported daily health at the between-person level. These effects are illustrated in Figure 5 (Panel A: positive affect, Panel B: loneliness). They indicate that participants who report poorer health but more frequent digital interactions report less loneliness than participants who report poorer health but less frequent digital interactions. Further, there was another significant interaction for frequency of digital interactions and self-

reported health complaints on positive affect at the between-person level ($\gamma = 5.99$, $CI = 1.93 - 1.04$, $p = .004$). This effect indicated that participants who report more health complaints, but have a higher frequency of digital interactions than other participants report more positive affect than those participants with more health complaints, but fewer digital interactions than other participants. Both interaction effects support our hypothesis.

Figure 5. Significant interaction effects of text-based digital interactions at the between-person level.



Notes: Below/above average frequency of telephone interaction indicates 1 SD deviation from the sample average of digital text-based interactions across the study period of 21 days. The outcome variables range from 0 to 100. The y-axis of the plot is adjusted to enhance readability, which may make differences appear larger than they are within the full potential range.

We repeated the analyses for the buffering effects to control for participants' age and gender. After adding control variables, our effects mostly remained the same with two exceptions: The interaction effect at the between-person level for frequency of telephone calls and health complaints on negative affect was no longer significant. However, there was a significant interaction effect at the within-person level for frequency of face-to-face interactions and health complaints on loneliness ($\gamma = -1.44$, $CI = -2.87 - -0.01$, $p = .049$), which was in line

with our hypothesis: It indicates that on days when participants report a health complaint, they report less loneliness when they report more face-to-face interactions.

Follow-Up Analyses

We further examined whether the pleasantness of social interactions in different modalities was related to daily well-being and buffered the adverse effects of poor health on well-being. Participants indicated how pleasant they perceived each conversation on a slider scale ranging from “not at all” to “very much” (0–100). These ratings were averaged across each day and modality and separated into between-person and within-person components. With few exceptions, a higher pleasantness of social interactions was related to more well-being in all three modalities. In summary, the results of the follow-up analyses showed that the pleasantness of social interactions did not more consistently buffer the effects of poor health on well-being than the frequency of social interactions did. More detailed results can be found in Table S1 and S2 and Figures S1 to S3 in the supplemental materials.

Discussion

The goal of the present study was to examine the association of daily variations in health on well-being and loneliness and to examine whether the frequency of social interactions in different modalities (face-to-face, telephone, text-based digital) buffers negative effects of poor health on daily well-being in older adults. Poor health was measured with two different variables, one examining the self-reported assessment of feeling healthy at the day of assessment while the other one indicated whether the participant reported any health complaints on the day of assessment. We also considered multiple facets of well-being, including daily positive and negative affect and loneliness.

In sum, our results are somewhat heterogeneous. We found evidence for our hypothesis that poor health was associated with lower daily well-being. Specifically, better self-reported health was associated with more positive affect, less negative affect and less loneliness both at the between- and the within-person level. In addition, more self-reported health complaints were associated with less positive affect, more negative affect, and more loneliness at the within-person level and unrelated to well-being at the between-person level. We were also able to replicate findings from previous studies that a higher frequency of daily face-to-face social interactions is associated with better well-being. In addition, a higher frequency of text based digital interactions was related to less negative affect and loneliness

between persons. In summary, we found main effects for health and social interactions on daily well-being.

The main interest of our study was to investigate possible buffering effects of social interaction frequency on adverse effects of poor health on well-being. We found several interaction effects supporting our hypothesis. With regard to face-to-face social interactions, we found that more frequent interactions buffer the relationship between poor self-reported daily health and daily loneliness. For telephone social interactions, we found that more frequent interactions buffer the relationship of poor self-reported health with positive affect and loneliness at the within-person level. In addition, more frequent telephone social interactions buffer the relationship between more health complaints and negative affect and loneliness at the between-person level. For text-based digital interactions, a higher frequency of interaction buffered the relationship between poor self-reported health and loneliness, and the relationship between more health complaints and positive affect, at the between-person level. One significant interaction effect contradicted the predictions of our hypothesis: The relationship between self-reported health and negative affect at the within-person level was stronger when a participant engaged in more frequent face-to-face social interaction on that day.

These results imply that daily variations in self-reported perceptions of health as well as health complaints are related to well-being. There is some evidence that this negative impact can be buffered through higher frequency of social interactions in different modalities. Even though our results are less clear than expected, they do show evidence that health-related concerns may adversely affect well-being, and that these adverse effects can be buffered by higher frequency of social interactions on the between- and the within-person levels.

Buffering Effects: The Role of Social Interaction Frequency in Different Modalities

We further hypothesized that frequency of face-to-face interactions would buffer against negative effects of poor health on well-being more consistently than the other modalities (telephone calls and digital interactions). Frequency of face-to-face interactions showed buffering effects exclusively for the self-reported health component and also exclusively at the within-person level. There were no significant buffering effects for the frequency of face-to-face interactions between persons and for health complaints.

The frequency of digital text-based interaction showed buffering effects at the between-person level, but not at the within-person level. This could imply that participants who use digital communication modalities to broaden their social activities perceive more social connection than participants who engage in digital communication less frequently. One possible explanation for this pattern of findings could be that digital communication increases the perception of social connection in general, however, more frequent digital social interactions in a single day do not necessarily enhance social connection the same way that other interaction modalities (e.g. face-to-face or telephone interactions) might. It is possible that a vastly higher frequency of digital text-based interactions is needed to provide the same social connection offered by face to face social interactions. This expectation can be derived based on the media richness theory (Daft & Lengel, 1983; Ishii et al., 2019) that face-to-face interactions offer richer socioemotional information. To reach the same effect on well-being, a higher amount of interactions in less rich modalities might be needed. Nevertheless, we could not confirm our hypothesis that face-to-face interactions would be superior to other modalities in their buffering effects: Frequency of face-to-face interactions does not have as clear of a buffering advantage over other modalities. Increasing one's digital social network could be beneficial: Although most older adults in industrialized countries use the internet and own a smartphone (Gaia et al., 2021), the benefits of using digital devices to interact socially with others is underutilized. The different effects of interactions in different modalities on well-being might also imply different mechanisms of showing and receiving social support via social interactions in different modalities. Future research should investigate the context and content of social support interactions taking place in different modalities. The results imply that a more nuanced examination of social interactions across different modalities is needed, because these interaction modalities may create different contexts for experiencing social support. However, it is important to note that we measured the frequency of social interactions, which does not directly equal to social support. Nevertheless, our finding that increased interaction frequency, without considering the qualitative aspects, can still buffer some of the adverse effects of poor health on well-being offers promising insights and potential directions for future research.

We conducted follow-up analyses to examine whether pleasantness of interaction in different modalities was associated with well-being and whether it showed buffering effects. Several studies indicated that, in addition to the frequency of social interactions, the quality of those interactions (Lin & Lachman, 2024) or the perceived satisfaction with the frequency of interaction (Hays et al., 1997) as well as the interaction partner (Sun et al., 2020), also plays a

crucial role for well-being. We found that in general, and in addition to health variables, pleasantness of social interaction was positively associated with well-being but only showed some buffering effects. Considering the main effects, pleasantness of social interactions was more consistently associated with well-being than frequency of social interactions, especially for interactions taking place via telephone. Nevertheless, it must be considered that phone calls were reported less frequently in relation to face-to-face and digital interactions, and differences in result patterns may also stem from this. Further, pleasantness of social interaction did not buffer adverse effects of poor health on well-being more consistently than the frequency of social interactions did. The interaction effects we found were only partly in line with our hypothesis. More research is needed on how pleasantness of social interactions are associated with well-being and health and under which circumstances it is more beneficial to enhance frequency of social interactions and when it is more beneficial to ensure high quality social interactions.

Our study further suggests that it is beneficial to differentiate not only between different interaction modalities, but also between different aspects of well-being. Our results show that buffering effects differ for positive and negative affect. Further, we found the largest number of buffering effects for adverse effects of poor health on loneliness, stressing the importance to study loneliness on a day-to-day basis. Our results also add to the literature on health sensitivity (Potter et al., 2022; Schöllgen et al., 2016) as they show that daily fluctuations in self-reported health and health complaints are not only related to daily positive and negative affect, but also to daily feelings of loneliness.

Limitations and Future Directions

In closing, we note some limitations to this study. First, in this study, we focused on the frequency of social interactions and did not consider other potentially relevant factors for buffering effects (e.g., context of the social interaction, content, interaction partner). Even though our follow-up analyses on pleasantness of social interactions also show a somewhat heterogeneous picture, future studies should focus on these factors in more detail to gain a more nuanced understanding. Examining the relationship with one's interaction partner or reasons for social interactions could be interesting in regard to expectations that individuals might have for the interaction and how this is related to well-being afterwards. Second, health was assessed with two single items each relying solely on self-report. Including objective health measures (e.g., biomarkers) would improve the understanding of the role of daily health for well-being. Additionally, if objective health measures were added a more clear

distinction between self-reported health and self-reported psychological assessments could be made as it could be argued that the self-reported health measures may also incorporate psychological health. Considering the health complaint variable, it might also be important to consider how long a specific complaint has been present and how restrictive it is for everyday life. Additionally, one could also argue that daily variations in health not only contribute to well-being, but that well-being itself may shape people's perceptions of their health. Our analyses did not account for the association of daily variation in well-being or daily social interactions on self-reported health. For example, more frequent social interactions with friends are associated with better health ratings (e.g. Fiorillo & Sabatini, 2011), indicating that social interaction frequency may also predict daily health. Future research should explore these associations. Third, even though this study adds to the literature by examining loneliness in addition to affective states, it could be interesting for future research to also look at other concepts of well-being such as life satisfaction (Adams et al., 2016) or sense of purpose (Weston et al., 2021) in this association with health and social interactions. Fourth, this study is based on a selective volunteer sample. Participants had a relatively high level of education and reported relatively good health. Moreover, one of our inclusion criteria was to be familiar with technology-mediated interaction modalities prior to our study. Our results may therefore not be suited to generalize to a broader population, especially not to older adults with low exposure to technology or who are at high risk of social isolation. Additionally, most of our participants were retired. Future studies should consider expanding on these results by including older adults from different backgrounds and with more variations in health complaints or comparing working and retired individuals.

Conclusion

In sum, our findings show that poor health is a risk factor for all aspects of well-being and provide some evidence that social interactions in different modalities can buffer negative consequences resulting from poor health for older adults' well-being in everyday life. More research is needed with a stronger focus on content and quality of the social interactions in order to identify how health-related stressors can be best addressed with different forms of social support and to derive recommendations for everyday behaviors.

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Appendix: Supplemental Online Materials

Follow-Up Analyses

We conducted follow-up analyses examining possible buffering effects of pleasantness of social interactions in different modalities on the association between poor self-reported health and well-being. Results are shown in Tables 1 (self-reported health) and 2 (self-reported health complaint). An overview of the buffering effects is shown in Figure 1. There was a significant interaction effect of pleasantness of face-to-face interactions and self-reported health on positive affect ($\gamma = 0.01$, $CI = 0.01 - 0.02$, $p < .001$) at the between-person level that was not in line with our hypothesis. Specifically, the effect of pleasantness of face-to-face interactions on positive affect was larger for participants with better self-rated health than others (see Figure 2, Panel A). There was another significant interaction effect of pleasantness of digital interactions and self-reported health on positive affect ($\gamma = -0.002$, $CI = -0.0044 - -0.0003$, $p = 0.023$) at the within-person level that was in line with our hypothesis. Specifically, the effect of pleasantness of digital text-based interactions on positive affect was larger when self-reported health was worse than usual (see Figure 2, Panel B).

For self-reported health complaints, there was a significant interaction for pleasantness of face-to-face interactions and positive affect ($\gamma = 0.10$, $CI = 0.004 - 0.206$, $p = .042$) at the within-person level that indicated that the pleasantness of face-to-face interactions buffered the effect of self-reported health complaints on positive affect (see Figure 3, Panel A). Further, there was a significant interaction of health complaints with the pleasantness of telephone calls ($\gamma = 0.29$, $CI = 0.09 - 0.49$, $p = .004$; illustrated in Figure 3, Panel B) and with the pleasantness of text-based digital interactions ($\gamma = 0.30$, $CI = 0.12 - 0.47$, $p = .001$; illustrated in Figure 3, Panel C) on loneliness at the within-person level. These effects were not in line with our hypothesis, because they indicated that the pleasantness of telephone and digital text-based interactions were related to lower loneliness at times of higher self-reported health complaints. Taken together, these findings suggest that the pleasantness of social interactions does not more consistently buffer the association between poor health and lower well-being than the frequency of social interactions does.

Table S1. Results from models examining the effects of self-reported daily health, pleasantness of face-to-face, telephone, and text-based digital interactions on positive and negative affect and loneliness as well as moderating effects of interaction pleasantness on the effects of self-reported daily health on well-being (interaction effects).

	Positive Affect			Negative Affect			Loneliness		
	Estimate	SE	p	Estimate	SE	p	Estimate	SE	p
Fixed Effects									
<i>Face-to-Face Social Interactions</i>									
Intercept	69.98*	0.81	<.001	14.19*	0.92	<.001	17.93*	1.04	<.001
Pleasant F2F (between-person)	0.46*	0.07	<.001	-0.30*	0.08	<.001	-0.33*	0.09	<.001
Pleasant F2F (within-person)	0.15*	0.02	.003	-0.19*	0.02	<.001	-0.20*	0.02	<.001
Health today (between-person)	0.29*	0.05	<.001	-0.28*	0.06	<.001	-0.34*	0.07	<.001
Health today (within-person)	0.30*	0.02	<.001	-0.11*	0.02	<.001	-0.14*	0.02	<.001
Pleasant F2F X Health Today (between-person)	0.02*	<.01	.001	0.00	0.01	.342	-0.01	0.01	.330
Pleasant F2F X Health Today (within-person)	-0.00	<.01	.399	0.00	0.00	.098	0.00	0.00	.972
<i>Telephone Social Interactions</i>									
Intercept	69.60*	1.03	<.001	14.14*	1.03	<.001	18.85*	1.20	<.001
Pleasant Tel (between-person)	0.26*	0.07	<.001	-0.23*	0.07	.002	-0.17*	0.08	.039
Pleasant Tel (within-person)	0.03	0.02	0.14	-0.09*	0.02	<.001	-0.00	0.02	.909
Health today (between-person)	0.34*	0.07	<.001	-0.29*	0.07	<.001	-0.38*	0.08	<.001
Health today (within-person)	0.36*	0.03	<.001	-0.16*	0.03	<.001	0.26*	0.03	<.001
Pleasant Tel X Health Today (between-person)	0.00	<.01	.833	0.00	<.01	.864	0.00	0.01	.748

Pleasant Tel X Health Today (within-person)	-0.00	<.01	.299	0.00	<.01	.878	0.00	<.01	.368
<i>Digital Social Interactions</i>									
Intercept	69.17*	1.02	<.001	13.49*	1.03	<.001	18.27*	1.27	<.001
Pleasant Dig (between- person)	0.27*	0.08	.001	-0.20*	0.08	.014	-0.15	0.10	.132
Pleasant Dig (within-person)	0.03	0.02	.254	-0.09*	0.02	<.001	0.00	0.03	.963
Health today (between- person)	0.32	0.07	<.001	-0.29*	0.07	<.001	-0.35*	0.09	<.001
Healthy today (within- person)	0.37*	0.03	<.001	-0.17*	0.03	<.001	-0.25*	0.03	<.001
Pleasant Dig X Health Today (between-person)	-0.01	<.01	.101	0.03	<.01	.478	0.00	0.01	.785
Pleasant Dig X Health Today (within-person)	-0.002*	0.00	.024	-0.00	<.01	.223	0.00	<.01	.790

Notes: γ = Estimate; SE = Standard Error; * $p < .05$.

Random intercepts and residual variances were estimated, but not included in this table.

Table S2. Results from models examining the effects of self-reported health complaint, pleasantness of face-to-face, telephone, and text-based digital interactions on positive and negative affect and loneliness as well as moderating effects of interaction pleasantness on the effects of self-reported health complaints on well-being (interaction effects).




	Positive Affect			Negative Affect			Loneliness		
	Estimate	SE	p	Estimate	SE	p	Estimate	SE	p
Fixed Effects									
<i>Face-to-Face Social Interactions</i>									
Intercept	71.20*	0.84	<.001	13.82*	0.90	<.001	17.51*	1.03	<.001
Pleasant F2F (between-person)	0.60*	0.07	<.001	-0.46*	0.08	<.001	-0.52*	0.09	<.001
Pleasant F2F (within-person)	0.19*	0.02	<.001	-0.21*	0.02	<.001	-0.22*	0.02	<.001
Complaint today (between-person)	-4.27	3.18	.184	4.80	3.41	.162	5.32	3.94	.180
Complaint today (within-person)	-7.21*	0.75	<.001	1.56*	0.70	.025	2.54*	0.84	.002
Pleasant F2F X Complaint Today (between-person)	-0.37	0.27	.170	0.18	0.30	.525	0.16	0.33	.641
Pleasant F2F X Complaint Today (within-person)	0.10*	0.05	.042	0.01	0.05	.768	-0.07	0.06	.215
<i>Telephone Social Interactions</i>									
Intercept	69.65*	1.11	<.001	14.04*	1.04	<.001	18.67*	1.25	<.001
Pleasant Tel (between-person)	0.32*	0.08	<.001	-0.30*	0.07	<.001	-0.24*	0.09	.006
Pleasant Tel (within-person)	0.05*	0.03	.037	-0.10*	0.02	<.001	-0.02	0.03	.468
Complaint today (between-person)	-2.87	4.46	.521	2.06	4.19	.624	2.87	5.02	.569
Complaint today (within-person)	-4.20*	1.47	.004	-0.46	1.31	.724	1.10	1.53	.474

Pleasant Tel X Complaint Today (between-person)	-0.25	0.33	.450	0.31	0.31	.319	0.38	0.37	.313
Pleasant Tel X Complaint Today (within-person)	-0.07	0.10	.463	0.16	0.09	.066	0.29*	0.10	.004
<i>Digital Social Interactions</i>									
Intercept	69.86*	1.07	<.001	13.71*	1.01	<.001	18.33*	1.26	<.001
Pleasant Dig (between-person)	0.43*	0.08	<.001	-0.32*	0.08	<.001	-0.30*	0.09	.002
Pleasant Dig (within-person)	0.05	0.02	.004	-0.11*	0.02	<.001	-0.02	0.03	.389
Complaint today (between-person)	-2.50	4.64	.591	5.44*	4.39	.219	5.04	5.45	.357
Complaint today (within-person)	-4.46*	2.56	.004	-0.97	1.40	.490	0.20	1.62	.904
Pleasant Dig X Complaint Today (between-person)	-0.05	0.31	.870	-0.17	0.29	.571	-0.22	0.36	.536
Pleasant Dig X Complaint Today (within-person)	-0.03	0.09	.771	0.15	0.08	.057	0.30*	0.09	.001

Notes: γ = Estimate; SE = Standard Error; * $p < .05$.

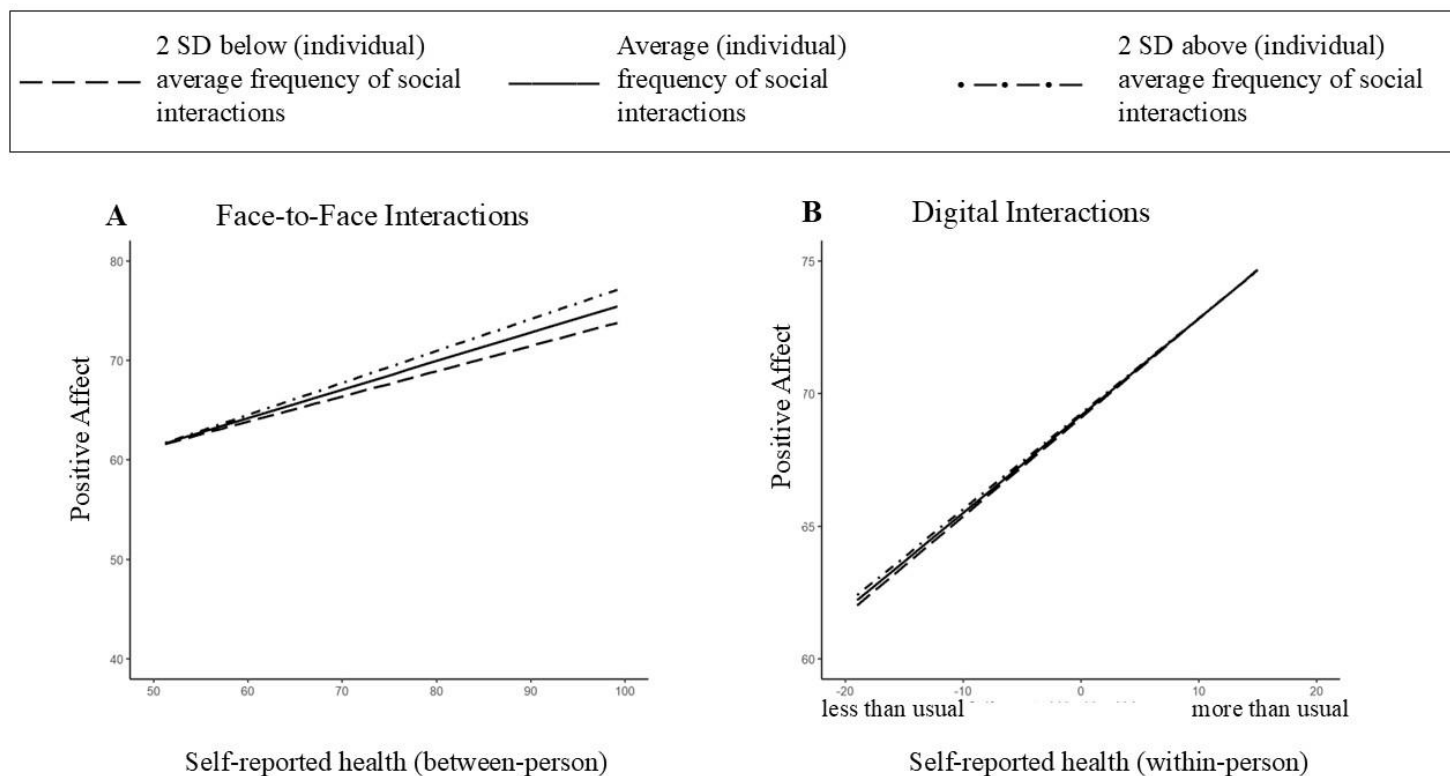
Random intercepts and residual variances were estimated, but not included in this table

Figure S1. Overview of buffering effects.

		self-reported health			self-reported health complaint		
Pleasantness of social interaction		Positive Affect	Negative Affect	Loneliness	Positive Affect	Negative Affect	Loneliness
	between-person	!	⊗	⊗	⊗	⊗	⊗
	within-person	⊗	⊗	⊗	✔	⊗	⊗
	between-person	⊗	⊗	⊗	⊗	⊗	⊗
	within-person	⊗	⊗	⊗	⊗	⊗	!
	between-person	⊗	⊗	⊗	⊗	⊗	⊗
	within-person	✔	⊗	⊗	⊗	⊗	!

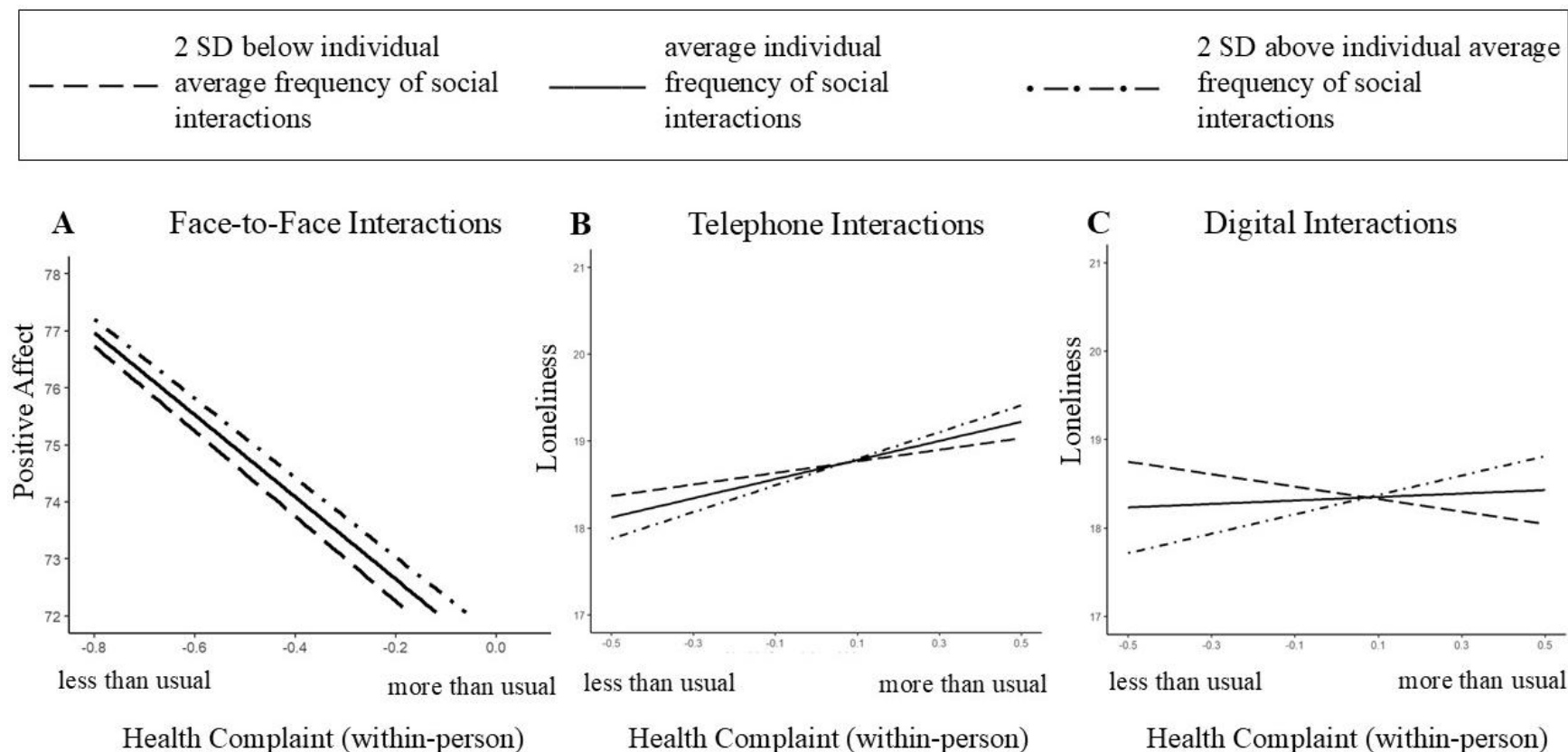
Notes: A checkmark indicates a significant interaction that confirms our hypothesis, a cross indicates no significant interaction, the exclamation point marks a significant interaction that goes against our hypothesis.

Figure S2. Significant interaction effects of the pleasantness of social interactions at the between- and within-person level on the association of self-reported health and well-being.



Notes: Below/above individual average indicates 2 SD deviation of the sample's/individual's own average of frequency of face-to-face interactions across the study period of 21 days. Because the moderation effects related to social interaction pleasantness were small, 2 SD were chosen to improve readability of figures. The y-axis of the plot is adjusted to enhance readability, which may make differences appear larger than they are within the full potential range.

Figure S3. Significant interaction effects of the pleasantness of social interactions on the association of health complaints and well-being at the within-person level.



Notes: Below/above individual average indicates 2 SD deviation of the individual's own average of pleasantness of social interactions across the study period of 21 days. Because the moderation effects related to social interaction pleasantness were small, 2 SD were chosen to improve readability of figures. The outcome variables range from 0 to 100. The y-axis of the plot is adjusted to enhance readability, which may make differences appear larger than they are within the full potential range.

Manuscript III

Data for this manuscript were drawn from the COVID study of the “Allies in Health” project, developed by Professor Dr. Christiane Hoppmann at the University of British Columbia. The concept of this research question and the data analysis for this manuscript were developed by myself with support from Professor Dr. Christiane Hoppmann. The literature search and manuscript preparation were done by myself. The data analysis was conducted by myself with support from Elizabeth Zambrano Garza. The first draft of the manuscript was written by myself and reviewed by Professor Dr. Christiane Hoppmann and Professor Dr. Gizem Hülür. The manuscript is currently under review at *GeroPsych*. It was submitted in this version on September 29, 2025. This version has not been peer reviewed.

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Study III: Partner Correspondence in Social Time Spent With One Another And Well-Being

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Electronic Supplemental Material: Pre-registered hypothesis can be accessed at https://osf.io/pnx52/?view_only=d699242ec18944e8adea48c0558ca28b. Analytic code can be accessed online at https://osf.io/pnx52/?view_only=35a6007fe07f49da9ac2d90e8aa5b3ba. Data can be made available upon request for verification purposes. More details of our follow-up analyses can be found in tables in online supplement.

Abstract

Social interactions - both in-person and digital - play an important role for older adults' daily well-being. A longer social interaction duration is related to higher well-being at the individual level. Less is known about how partners' perceptions of shared time differ and whether the degree and direction of potential discrepancies in perceptions are related to well-being. We hypothesized that more time spent together would be associated with higher well-being. We examined whether overreporting shared time compared to a partner (in line with the positive illusion literature) or whether a greater accuracy in time reports between partners would be associated with elevated well-being. This study uses dyadic diary data from 140 Canadian older adults and a close other of their choice ($M = 66.68$ years, $SD = 13.11$ range: 18-87 years, 60% women). Correlational results show that partners differ in their report of time spent together. In line with previous work, more time spent with others in-person is associated with higher well-being. Contrary to our hypothesis, multilevel models show that overreporting is associated with lower well-being. Follow-up analyses showed that this association is stronger with older age. Higher accuracy is not associated with higher well-being. Our results suggest that perceiving to have more time with one's study partner than the partner does is not as consistently associated with better well-being as we expected. Perhaps other aspects of spending time with one another are more important for well-being. Differences in time perception might further be affected by individual differences like age.

Key words: social interaction, older adults, dyadic, accuracy, well-being,

Introduction

Feeling connected to other people is a basic human need (Baumeister & Leary, 1995) that can be fulfilled by spending time with close others. Socially interacting with others is associated with higher levels of positive affect, lower levels of negative affect, and higher life satisfaction (Luo et al., 2022; Sacco & Ismail, 2014). To date, much of this work is based on individual reports of social interactions, disregarding the perspective of the interaction partner (Y. K. Kim & Fingerman, 2022; Skalačka & Pajestka, 2021). The perception of how much time is spent interacting with close others might be shaped by cognitive biases, such as positive illusions that idealize relationship partners (Murray et al., 1996; Taylor & Brown, 1994). In other words, cognitive biases need not be negative. In fact, they may be an active ingredient of a satisfying relationship (Murray et al., 1996) and thus be an important aspect of daily well-being. This study extends past work by examining the role of individual and partner reported time spent together as well as their convergence for everyday fluctuations in well-being of both members of a dyad. Specifically, we investigated if individuals, who report having spent more time with a close other, than what that close other reported, would report higher well-being, relative to individuals, whose time reports were similar to those that their partners reported. Previous research suggests that there are differences in the effect of social interaction frequency on well-being depending on the interaction modality (Grünjes et al., 2024). Thus, we examine time spent together with a close other in-person and digitally. Further, we study time spent with a close other during the COVID-19 pandemic, when in person social contact was limited and digital contact was encouraged (World Health Organization, 2020).

Social Interactions and Well-Being

Connecting socially with others is associated with higher well-being: A greater frequency of social interactions is associated with more positive affect (Lin & Lachman, 2021), less negative affect and loneliness (Luo et al., 2022), and better mood (Y.K. Kim & Fingerman, 2022). With technology advancing, digital interaction modalities have become part of our daily lives and accompany face-to-face interactions in our encounters with others (Y.K. Kim & Fingerman, 2022). According to the Pew Research Centre (2024) around 75% of older adults in Canada use digitally mediated communication tools in their daily lives. There is evidence that interacting using digital modalities contributes to older adults' everyday well-being (Lee et al., 2022; Macdonald et al., 2021) even though it is less consistently associated with well-being than face-to-face interactions (Sacco & Ismail, 2014). Collecting data during

the COVID-19 pandemic provides a unique backdrop to this study since in-person contact was oftentimes limited due to governmental restrictions and an increase in digital contact could be observed (Tomaz et al., 2021). In line with previous studies (R. Sun et al., 2022), we expected that longer face-to-face and digital social interactions would both be associated with higher well-being in older adults. Most previous research focuses on interaction frequency (as in number of interactions) during a day (Skalacka & Pajestka, 2021), whereas this study measures total time spent with a partner during a day. By this, we aim to consider more than the occurrence of a social event but more so the duration during the day.

Social Interactions in Old Age

Social relationships and interactions are key to well-being in old age. According to the Socioemotional Selectivity Theory (Carstensen et al., 1999), as people age, they perceive their time as more limited. As a result, people tend to focus more on close relationships and emotionally meaningful social interactions over knowledge-seeking goals and novel interactions (English & Carstensen, 2014; Wrzus et al., 2024).

Most previous research on close relationships focuses on spouses, overlooking the broader spectrum of close relationships and failing to account for the substantial proportion of older adults who do not live in a marriage-like partnership. Many older adults either do not have a romantic partner or lost them in the course of their lives through divorce, illness, or death (Brown & Lin, 2012; Rook & Charles, 2017). This study builds on previous work on close relationships in old age without restricting the focus to romantic partners by allowing older adults to participate with a close other of their choice.

Positive Illusion Theory and Dyadic Structure

Previous studies on associations between social interactions and well-being are mostly focused on individual reports of the interaction, such as pleasantness, (Lin & Lachman, 2021; Macdonald et al., 2021) or length (Y. K. Kim & Fingerman, 2022), neglecting the viewpoint of the interaction partner(s). This is restricting because individual and partner reports about their relationships need not be identical (Kenny & Acitelli, 2001; O'Rourke et al., 2010). Overreporting has been studied in regard to joint goal setting in older couples: perceiving more goals as joint than the partner (overreporting) has been shown to be associated with higher relationship quality (Ungar et al., 2021). To our knowledge, overreporting has not been studied in regards to well-being and social interactions in dyads in a close relationship. Research suggests that idealized views of a partner predict greater relationship satisfaction

and happiness (Murray et al., 1996). Holding so-called positive illusions (Taylor & Brown, 1994) may be associated with higher well-being in relationships. Beneficial outcomes of positive illusions are not exclusive to close social relationships: Older adults who report positive illusions about their own aging also report higher satisfaction with leisure time and better subjective health (Gana et al., 2004). Bertrand (2023) found that romantic partners are strongly, but not perfectly congruent in the perception of time that is spent together or apart on daily activities, indicating that there is more to unpack. Based on the positive illusion literature (Murray et al., 1996) and studies pointing to the benefits of more (e.g. Lin & Lachman, 2021) and longer (R. Sun et al., 2022) social interactions for well-being, we expect that perceiving to have spent more time with a close other can be beneficial for well-being and overestimating the time in relation to a partner's reports (overreporting) is also associated with well-being.

The Present Study

This study examines how individual and partner reports of time spent together differ in dyads and how such differences may be related to their daily well-being. Further, we examine reports of time spent together in two different modalities: face-to-face and digital. Taking into account the perspectives of both partners using daily data from both members of a dyad creates parallel data streams that allow us to investigate both partners' views on their time together and their well-being in an ecologically valid fashion (Hoppmann & Riediger, 2009).

Thus, we are able to consider both partners' individual assessments as well as discrepancies in the perception between both members of the dyad. Thus, we propose the following research questions:

RQ 1.1: We expect differences between study partner reports of how much time they spent together during the day in both modalities.

RQ 2.1: We expect that participants who report to have spent more time with their study partner in relation to the study partner's own report (overreporting) to show elevated well-being (more positive affect and less negative affect and loneliness).

RQ 2.2: On days, when an individual overreports the time spent with their study partner more than usual, we expect elevated well-being.

To examine whether associations between reporting more time in relation what one's partner reports and well-being stem from overestimating time spent together (overreporting) or from

general undirected differences in time reports between partners (discrepancy) we also examine the association of the extent of differences in time reports and daily well-being. Those research questions are exploratory.

RQ 3.1: Is the extent of discrepancy in partner reports of time spent together associated with well-being?

RQ 3.2: Do the extent of discrepancy in time reports and the extent of discrepancy in well-being reports correlate between partners?

To address well-established correlates of both social interactions and well-being, we also control for age, gender, and health status at baseline (H. H. Kim & Jung, 2021; J. Sun et al., 2020) and for co-habiting since the COVID-19 pandemic came with restrictions to social contact (World Health Organization, 2020).

Methods

Participants

Participants for this study were recruited via online resources and community organizations across Canada. Participants had to be able to communicate verbally, read newspaper-sized print, and have access to a device with internet connection to be eligible for participation. All participants were recruited with a study partner, as the study was focused on dyadic relationships. One of the individuals had to be 65 years or older, the chosen study partner could be any age above 18 years. More detailed information can be found in previous publications with the same data set (Zambrano Garza et al., 2024a, 2024b, 2024c). We use data from 137 dyads ($M_{\text{age}} = 66, 12$; $SD = 11,05$; range: 18 - 87; 70% identified as women). 58% of our dyads were spouses, 33% were living together. In total, 72% of our participants were married, 69% were retired. 53% of our sample rated their general health as “very good” or “excellent”. Of the total 144 dyads that signed up for the study, we had to exclude two dyads either due to missing baseline information or missing evening questionnaires. Five other dyads were not included in the multilevel-models due to missing data in the (in-)dependent variables. As a thank you, each participant received an Amazon voucher worth \$50 Canadian dollars. The study was approved by the Behavioral Research Ethics Board of the University of British Columbia (H20-01645), and participants provided informed consent. The final sample completed 75.4% of their evening diaries ($SD = 2.55$, range: 2–10).

Procedures

Data were collected between June 2020 and June 2021. Participants took part in a phone screening and an instructional Zoom meeting. All participants provided background information in a baseline online questionnaire and up to 10 days of daily diary questionnaires.

Materials

Daily well-being. Positive and negative affect were assessed each evening asking participants to rate 10 positive and 9 negative valenced items each on a scale from 0 (not at all) to 100 (very much; Lay et al., 2019; Tsai et al., 2006). Items for the positive affect scale included adjectives like “happy”, “calm”, “content” and “enthusiastic” ($M_{\text{positiveAffect}} = 60.79$, $SD = 19.68$). The scale for negative affect included adjectives like “sad”, “overwhelmed”, and “nervous” ($M_{\text{negativeAffect}} = 15.65$, $SD = 15.52$). Loneliness was assessed using two daily items, “lonely” and “isolated” ($M_{\text{Loneliness}} = 11.2$, $SD = 18.15$). Reliability for positive affect was very good at the within-person level ($\omega = .829$) and excellent at the between-person level ($\omega = .943$). Reliability for negative affect was very good at the within-person level ($\omega = .803$) and excellent at the between-person level ($\omega = .964$). Reliability for loneliness was low at the within-person level ($\omega = .417$) and excellent at the between-person level ($\omega = .958$).

To assess discrepancies in reports of well-being between partners, we deducted partner reported daily well-being from the individual-reported daily well-being creating three new scores (for positive affect, negative affect, and loneliness) using the absolute difference in these reports. The smaller the value of those variables, the less discrepancy the dyads show in their daily well-being (discrepancy in reports of positive affect: $M = 19.55$, $SD = 15.85$; negative affect: $M = 13.86$, $SD = 13.97$; loneliness: $M = 13.01$, $SD = 18.14$). These variables were separated into time-invariant and time-varying components (Bolger & Laurenceau, 2013): the between-person component was calculated as the average absolute difference between the individual and the partner report in well-being, the within-person component was the daily deviation from this average indicating whether on this day, individual and partner were more or less similar in their daily well-being reports than usual.

Time spent with study partner and overreporting. To measure how much time participants spent with their study partner in each modality, they were asked to answer how much of their waking time they had spent with their study partner that day. Participants indicated the time in hours and minutes separately for face-to-face and digital modalities. We then converted hours and minutes into one variable for each modality that measured time spent interacting with

one's study partner in minutes ($M_{\text{face-to-face}} = 316.87$ minutes; $SD = 292.46$ minutes; $M_{\text{digital}} = 21.98$ minutes; $SD = 101.04$ minutes). To assess whether individuals overreported time spent with their study partner compared to their study partner's own report, we created a new set of variables by deducting partner reported time from individual-reported time. We did this separately for the face-to-face and digital modalities ($M_{\text{face-to-face}} = 84.70$ minutes; $SD = 133.44$ minutes; $M_{\text{digital}} = 15.22$ minutes; $SD = 69.42$ minutes). If the variable was positive, it indicated that the individual reported more time spent with the partner than the partner (overreporting).

To capture discrepancy, we used the absolute difference between reports: the higher the value of this variable, the more discrepant the two partners were in their assessment of the time they spent interacting with one another ($M_{\text{face-to-face}} = 112.44$ minutes; $SD = 143.23$ minutes; $M_{\text{digital}} = 24.4$ minutes; $SD = 86.6$ minutes). Variables were separated into time-invariant and time-varying components (Bolger & Laurenceau, 2013) to examine intraindividual and interindividual effects.

Covariates. Covariates included gender (0=man, 1=woman), age of the participant ($M_{\text{age}} = 66.24$, $SD = 13.74$), self-rated health at baseline and whether the dyad was living together (0 = no; 1 = yes). Relationship Quality. In follow-up analyses, we examined whether relationship quality moderates the association between interaction time reports and well-being. We assessed relationship quality using the Quality of Relationship Inventory (Pierce, 1994; Pierce et al., 1991), with subscales for support and conflict (Verhofstadt et al., 2006). We converted the 4 point Likert-type scale to a 5-point Likert-type scale (1 = "not at all"; 5 = "very much") and changed the term "this person" to "your study partner" as we were interested in the relationship between our participant and their study partner. Reliability for the conflict subscale was excellent ($\alpha = .93$). Participants reported relatively low levels of conflict ($M_{\text{conflict}} = 1.99$; $SD = 0.75$). Reliability for the support subscale was good ($\alpha = .84$). Participants reported high levels of support ($M_{\text{support}} = 4.21$; $SD = 0.68$).

Statistical Analyses

Data were analyzed using multi-level models based on up to 10 occasions of data per participant. To account for the hierarchically nested structure of the data, the models consisted of three levels (dyad, person, and day) to examine associations of daily time reports and daily overreported time spent with the study partner within dyads (face-to-face and digitally mediated) with daily well-being (positive and negative affect and loneliness). We examined origins of variability for positive affect (46% at the day level, 32% at the person level, and

22% at the dyad level), negative affect (53% at the day level, 32% at the person level, and 15% at the dyad level) and loneliness (45% at the day level, 23% at the person level, and 32% at the dyad level). The multi-level models were estimated in R (R Core Team, 2018) using the lme4 package (Bates et al., 2015). For all variables at the day-level, we added person-centered and grand-mean centered person-means to examine intraindividual variation (within-person effects) and interindividual variation (between-person effects; Bolger & Laurenceau, 2013). The between-person component was calculated as the average of an individual's time series, indicating an average of reported time or overreported time spent with the study partner over the study period of 10 days. The within-person components were calculated as the daily deviation from this average. We included the individual's age, gender, health status, and living together as control variables. Hypotheses for this study were preregistered at https://osf.io/pnx52/?view_only=d699242ec18944e8adea48c0558ca28b. To account for transparency of research principles, the analytic code can be accessed online at https://osf.io/pnx52/?view_only=35a6007fe07f49da9ac2d90e8aa5b3ba.

Results

First, we examined correlations between the covariates, the time report variables indicating overreporting and discrepancy and the well-being variables. Older age was associated with higher positive affect ($r = .25$), lower negative affect ($r = -.33$) and loneliness ($r = -.18$), more overreporting face-to-face time with one's study partner ($r = .18$), and greater discrepancies in reports of face-to-face time with one's study partner ($r = .20$). Overreporting digital time was associated with less positive affect ($r = -.19$) and also more negative affect ($r = .18$) and loneliness ($r = .17$). Higher discrepancies between partners in their reports of digital time were associated with less positive affect ($r = -.17$) and more negative affect ($r = .22$) and loneliness ($r = .17$). Discrepancies in reports on digital time were associated with lower positive affect ($r = -.11$) and higher negative affect ($r = .14$) and loneliness ($r = .11$). More details are provided in Table S1 in the supplemental materials.

Table 1. Results from multi-level models examining associations of reported time spent interacting with one's study partner, overreporting this time, and the extent of discrepancy in time reports between study partners, on well-being.

	Positive Affect		Negative Affect		Loneliness	
<i>Predictors</i>	<i>Estimate</i>	<i>SD</i>	<i>Estimate</i>	<i>SD</i>	<i>Estimate</i>	<i>SD</i>
<i>Time spent Face-to-Face</i>						
<i>Overreporting</i>						
Intercept	60.541*	1.040	16.376*	0.843	11.296*	1.074
Age	0.211*	0.069	-0.241*	0.059	-0.134	0.067
Gender	-2.943	1.916	2.727	1.632	2.339	1.815
Health	5.450*	1.012	-3.072*	0.846	-0.626	0.980
Living Together	1.930	2.997	-0.218	2.443	-1.927	3.042
Reported Time (between-person)	0.009	0.006	-0.011*	0.005	-0.010*	0.006
Reported Time (within-person)	0.006	0.003	-0.001	0.003	-0.005	0.003
Overreport (between-person)	-0.025*	0.012	0.029*	0.010	0.038*	0.012
Overreport (within-person)	-0.000	0.004	0.003	0.003	0.003	0.004
<i>Discrepancy</i>						
Intercept	60.896*	1.042	16.549*	0.800	11.615*	1.021
Age	0.242*	0.069	-0.275*	0.057	-0.197*	0.068
Gender	-1.887	1.840	2.049	1.529	1.570	1.805
Health	5.149*	0.969	-2.987*	0.796	-0.884	0.969
Living Together	3.816	3.045	-1.171	2.452	-3.829	3.086

Reported Time (between-person)	0.006	0.006	-0.008	0.005	-0.006*	0.065
Reported Time (within-person)	0.004	0.002	-0.004*	0.002	-0.005*	0.002
Discrepancy (between-person)	-0.022	0.012	0.022*	0.010	0.034*	0.012
Discrepancy (within-person)	0.003	0.002	0.004	0.002	0.001	0.002

Time spent digitally

Overreporting

Intercept	60.477*	1.036	16.633*	0.811	12.063*	1.078
Age	0.234*	0.069	-0.272*	0.058	-0.151*	0.069
Gender	-2.129	1.888	2.151	1.636	1.337	1.859
Health	5.233*	1.009	-3.139*	0.839	-0.464	1.014
Living Together	3.429	2.330	-0.605	1.836	-1.436	2.399
Reported Time (between-person)	0.027	0.663	-0.044	0.048	-0.001	0.161
Reported Time (within-person)	0.031	0.031	-0.004	0.025	-0.019	0.028
Overreport (between-person)	-0.058	0.062	0.049	0.045	0.031	0.056
Overreport (within-person)	-0.042	0.031	0.012	0.024	0.023	0.029

Discrepancy

Intercept	60.770*	1.001	16.677	0.806	11.705	1.045
Age	0.225*	0.068	-0.260*	0.056	-0.164*	0.066
Gender	-1.893	1.833	2.582	1.531	1.480	1.781
Health	5.018*	0.984	-2.891*	0.809	-0.620	0.979
Living Together	2.943	2.217	-0.706	1.792	-0.916	2.295

Reported Time (between-person)	-0.024	0.024	-0.017	0.019	0.019	0.022
Reported Time (within-person)	-0.012	0.007	0.007	0.006	0.004	0.006
Discrepancy (between-person)	-0.005	0.020	0.033*	0.016	0.017	0.020
Discrepancy (within-person)	0.003	0.006	-0.003	0.004	-0.001	0.005

Notes: $N_{individual} = 274$; $N_{dyads} = 137$; observations = 2113; $p < .05$

The number of observations and individuals varies slightly between models due to differing patterns of missing data in the dependent/independent variables. All models are estimated based on complete cases.

Associations Between Time with Study Partner and Daily Well-Being

In addition to testing our hypotheses, we sought to replicate earlier findings on the beneficial effects of time spent with others on well-being. Our multilevel models including reported time and control variables and their associations with well-being outcomes are partially in line with earlier findings (R. Sun et al., 2022). We found significant associations of time spent with one's study partner face-to-face with negative affect ($\gamma = -0.011$, $SD = 0.005$, $p = .029$), and loneliness ($\gamma = -0.010$, $SD = 0.006$, $p = .004$) at the between-person level, indicating that more face-to-face time was associated with better well-being. We did not find significant within person effects which is not in line with previous research (e.g. Grünjes et al., 2024). We did not find significant associations between spending time with one's study partner digitally and well-being, which adds to the heterogenous landscape on effects of digital interaction modalities and well-being.

Associations Between Overreporting and Well-Being

To test our hypothesis that overreporting time spent with one's study partner would be associated with increased daily well-being (RQ 2.1 and 2.1), we ran multilevel models with the daily well-being variables as outcomes. Results are reported in Table 1. Overall, most associations were not significantly different from 0. The significant associations were not in line with our hypothesis that overreporting is a form of positive illusion and therefore beneficial for well-being. Reporting more face-to-face time in relation to the partner's report was related to less positive affect ($\gamma = -0.025$, $SD = 0.012$, $p = .045$), more negative affect ($\gamma = 0.029$, $SD = 0.010$, $p = .005$) and loneliness ($\gamma = 0.038$, $SD = 0.012$, $p = .004$) at the between person level indicating that participants who were more likely to overreport face-to-face time relative to other participants, also reported less positive affect and more negative affect and loneliness. Again, there were no significant within-person effects. Reporting more digital time in relation to the partner's report was unrelated to well-being.

Table 2. Means, standard deviations, and correlations with confidence intervals

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7
1. Age	66.14	13.75							
2. Gender	0.65	0.50	-.22*						
3. Health	3.55	0.95	.05	-.07					
4. Discrepancy in Positive Affect reports	19.51	11.30	.08	.00	-.15*				
5. Discrepancy in Negative Affect reports	14.23	10.66	-.14*	.03	-.11	.39*			
6. Discrepancy in Loneliness reports	13.85	14.51	-.13*	.05	-.10	.21*	.57*		
7. Discrepancy in face-to-face reports	107.41	104.50	.20*	-.24*	.07	.04	-.03	.08	
8. Discrepancy in Digital reports	30.86	76.20	-.12	.04	-.20*	.01	-.08	.13*	-.06

Notes: *M* and *SD* are used to represent mean and standard deviation, respectively. $N_{individual} = 274$; $N_{dyads} = 137$; * indicates $p < .05$

Associations Between Discrepancies in Partners' Time Reports and Daily Well-Being

We examined whether discrepancies in the perception of time spent together would be associated with well-being. We used multilevel models with the individual's well-being variables as outcomes and the extent of discrepancy in reports of face-to-face or digital time spent with one's study partner as predictors (RQ 3.1). Results are reported in Table 1. Larger discrepancies between partners in reports of face-to-face time were associated with more negative affect ($\gamma = 0.022$, $SD = 0.010$, $p = .027$) and more loneliness ($\gamma = 0.034$, $SD = 0.012$, $p = .075$) at the between-person level. That is, individuals who are less similar in their perception of face-to-face time with their study partner reported more negative affect and more loneliness than participants who report less discrepant time perceptions. Further, a larger discrepancy between partners in their reports of digital time was associated with more negative affect ($\gamma = 0.033$, $SD = 0.016$, $p = .035$) at the between-person level. We conducted Pearson correlations to see whether the extent of discrepancies in time reports and well-being reports between partners were correlated (RQ 3.2). Except for a positive correlation between extent of discrepancy in reports of time spent digital and the extent of discrepancy between loneliness reports ($r = .13$), there were no significant correlations (Table 2).

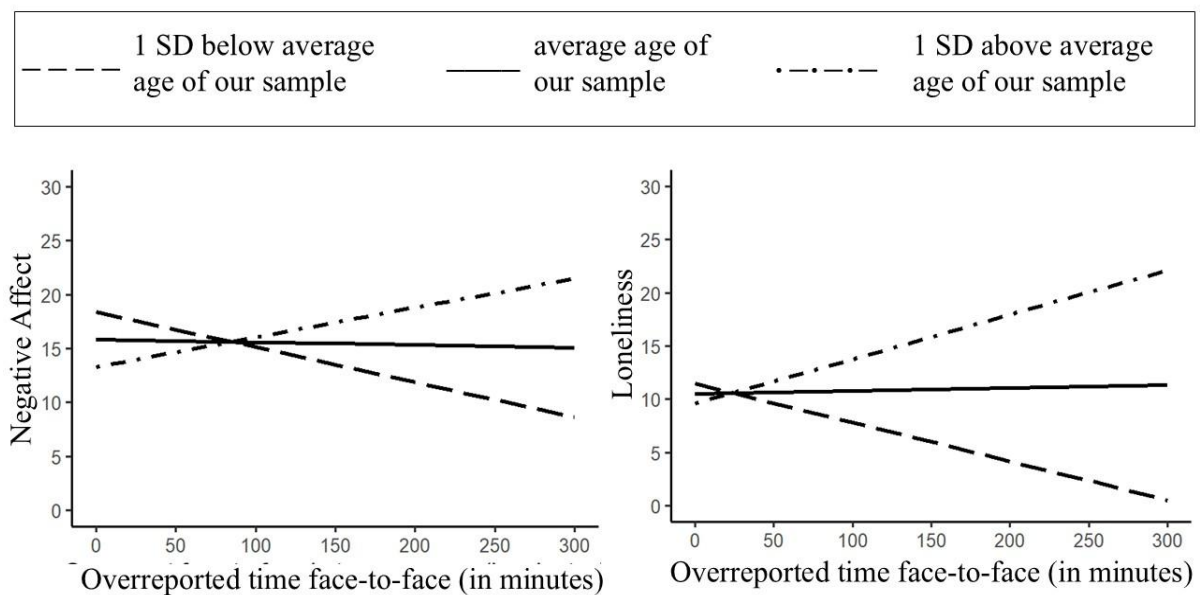
Follow-Up Analyses

Given the inconsistency between our hypotheses and findings, we conducted several follow up analyses that considered more characteristics of the dyad's relationship (conflict and support) and the individual (age). We conducted multi-level analyses that assessed whether conflict or support in the relationship with the study partner or the individual's age was associated with well-being and whether those factors might moderate the effect of overreporting time spent together on well-being. Because our participants reported only little time spent with one another digitally, we performed these analyses for time spent face-to-face only. Results can be found in tables S2 and S3 in the supplemental materials.

Individual characteristics. Older age was associated with more positive affect ($\gamma = 0.226$, $SE = 0.075$, $p = .003$) and less negative affect ($\gamma = -0.183$, $SE = 0.058$, $p = .002$) and unrelated to loneliness. We found two significant interaction effects of age on the association between overreporting the time spent face-to-face with one's study partner and well-being: Participants who reported more time spent with their study partner in relation to the study partner's report also reported more negative affect ($\gamma = 0.002$, $SE = 0.001$, $p = .001$) and more loneliness ($\gamma = 0.003$, $SE = 0.001$, $p < .001$) at the between-person level and this association was stronger for older participants (figure 1). In addition, we found two significant moderating effects of age

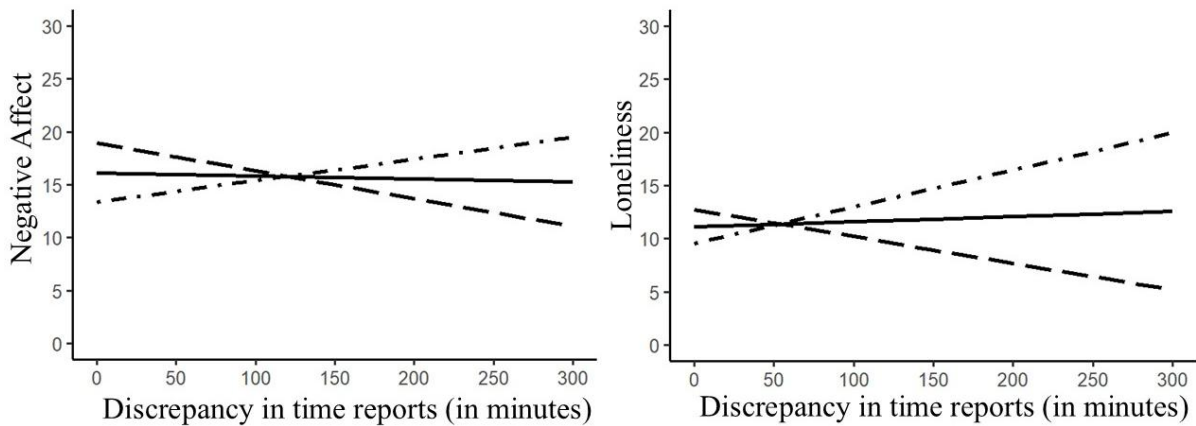
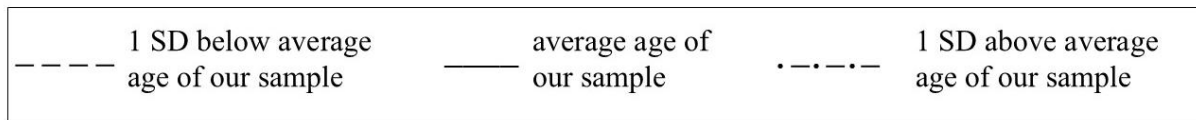
on the associations between the extent of discrepancy in reports of time spent face-to-face and negative affect and loneliness: A higher extent of discrepancy in reports of time spent with one's study partner face-to-face was associated with more negative affect ($\gamma = 0.002$, $SE = 0.001$, $p = .009$) and more loneliness ($\gamma = 0.002$, $SE = 0.001$, $p = .005$) for older participants (Figure 2). Figure 1. Illustrating significant interaction effects of the individual's age on the association of overreporting time spent with one's study partner face-to-face (between-person) and well-being.

Figure 1. Illustrating significant interaction effects of the individual's age on the association of overreporting time spent with one's study partner face-to-face (between-person) and well-being.



Notes: The outcome variables range from 0 to 100. The y-axis of the plot is adjusted to enhance readability, which may make differences appear larger than they are within the full potential range. Mean Age = 66.14 years, -1 SD = 52.39 years, + 1SD = 79.89

Figure 2. Illustrating significant interaction effects of the individual's age on the association of discrepancy in reports of how much time study partners spent together face-to-face (between-person) and well-being.



Notes: The outcome variables range from 0 to 100. The y-axis of the plot is adjusted to enhance readability, which may make differences appear larger than they are within the full potential range. Mean Age = 66.14 years, -1 SD = 52.39 years, + 1SD = 79.89

Relationship Quality. Higher levels of support within the relationship were associated with more positive affect ($\gamma = 4.223$, $SE = 1.419$, $p = .003$) and less negative affect ($\gamma = -4.024$, $SE = 1.114$, $p < .001$) and loneliness ($\gamma = -2.779$, $SE = 1.399$, $p = .048$). More conflict in the relationship was associated with more negative affect ($\gamma = 3.494$, $SE = 1.087$, $p = .002$). There were no significant interaction effects of relationship quality on the associations between overreporting/discrepancy and well-being.

Discussion

The present study investigated how individual perceptions of time with a close other and differences between study partners' perceptions of time together are associated with daily well-being. We hypothesized that more time spent with one's study partner would be associated with elevated well-being. Based on this assumption and the positive illusion literature, we further hypothesized that participants who perceived to have spent more time with their study partner in relation to what the partner reported (overreporting) would report higher well-being. Further, we explored how the extent of discrepancy in time reports between partners is associated with well-being and with partner discrepancies in well-being reports. We found that more time spent in person with one's study partner was associated with elevated well-being. Our hypothesis concerning the positive illusion theory was not

confirmed: To the contrary, we found that overreporting time spent with one's study partner face-to-face was associated with lower well-being.

Associations of Time Spent with One's Study Partner and Well-Being

We partially replicated findings from previous studies indicating spending more time face-to-face with one's study partner was associated with elevated daily well-being (Grünjes et al., 2024; R. Sun et al., 2022). We added to this line of research by finding evidence for longer duration of face-to-face contact being associated with higher well-being as previous studies mostly focused on the association between higher frequency of social interactions and well-being. However, we did not find similar results for time spent digitally with one's study partner. This adds to the somewhat heterogeneous landscape: While some studies also did not find significant associations, other previous studies report that, even though face-to-face social interactions are more consistently associated with well-being (Sacco & Ismail, 2014; J. Sun et al., 2020), more frequent digital social interactions still show beneficial and even compensating effects for well-being (Grünjes et al., 2024; Lee et al., 2022). However, differences in findings might stem from differences in measurement, as many other studies measure in frequency of interaction occurrence and this study measured duration in minutes.

Associations of Overreporting and Well-Being

Based on the positive illusion literature (Murray et al., 1996) and previous results that more time with a close other and more social interactions are associated with higher well-being at the individual level (R. Sun et al., 2022), we expected overreporting time spent with one's study partner to be associated with elevated well-being. However, we found significant associations of overreporting time with one's study partner face-to-face in the opposite direction, suggesting that overreporting is associated with less positive and more negative affect and loneliness at the between-person level.

A potential explanation behind this finding could be based on our measure of self-reported time: Possibly, perceptions of time are affected by several other factors that we did not account for (e.g., people could have different perceptions of time in general, experiences during the time spent together or apart might have played a role). A daily assessment study by Droit-Volet and Wearden (2015) found that individual perceptions of time passing were significantly correlated with the affective state they were in at the time of the report. Higher arousal and more positive affect were associated with evaluating that time passes more quickly, whereas low arousal and more negative affect were associated with perceiving time to pass more slowly. These results indicate differences in time assessment do not only exist

between individuals, but are sensitive to the specific context and vary within the same day depending on contextual factors and affective states. Thus, one could argue that differences in retrospective assessments of time may differ between partners due to differences in the interpretation on a relationship level, but also that such differences might be due to other aspects outside the dyad.

Another possible explanation could be that overreporting reflects a mismatch between expectations and actual experiences in a relationship: Potentially, the individual has a desire for more closeness or to spend more time with the study partner, but these needs are not met properly, thus resulting in a negative effect on well-being. As the data was collected during the COVID-19 pandemic, social contact outside of very close relationships or one's own household, were limited. Research suggests that once a certain amount of daily social contact is surpassed, its positive effects on well-being decrease (Luo et al., 2022). Potentially, given the unique situation, our participants surpassed the critical point with their study partner more often during the pandemic which lead to experiencing more time (or perceiving more time) as negative.

Moreover, time was probably spent differently face-to-face and digitally, which makes the two modalities harder to compare in our scenario. Further, interacting digitally can also happen asynchronously, meaning that one sends a text message and the other does not respond immediately which can make estimates about time more challenging. Some people are quicker in operating a cell phone than others causing more noise in interpreting those indicators. Since our participants reported a much higher number of minutes spent face-to-face with their study partner than digitally, even during a time of social distancing, any results on associations of time spent digitally should be interpreted with caution.

Nevertheless, one can draw two conclusions from this observation. First, even in times of limited possibility to connect with others, people are able to stay close to others and thus can enhance their well-being by spending time with them. Second, since research has shown that connecting with close others digitally can be beneficial for well-being as well (Grünjes et al., 2024; Lin & Lachman, 2021), mechanisms behind this association should be investigated further; however, not necessarily by measuring duration of interaction time. Other possibilities would be to focus on frequency, pleasantness (Macdonald et al., 2021), or meaningfulness (Nikitin et al., 2024) of the interaction because the actual time spent with a close other might not be the most relevant aspect. Moreover, the quality of time spent together is not limited to social interactions but might also be influenced by other activities such as

doing chores or leisure activities that might be more relevant in the association with well-being and should therefore be assessed separately instead of mixed together.

Associations Between Discrepancies in Partner's Time Reports and Well-Being

Next, we examined whether partner discrepancies in time reports were associated with well-being as well as discrepancies in their well-being reports. Again, for the most part we did not find significant associations which could be related to interpersonal differences in time perceptions in general or due to situational circumstances, as noted above. There was an association between a higher discrepancy in digital time reports and more negative affect at the between-person level. As participants reported low amounts of time spent digitally in general, these results are difficult to interpret. Further, digital literacy or technical skills might vary drastically in older age (Hargittai et al., 2019) leading to different amounts of time needed to carry out the same digital activity, further blurring the lines as to why we found those effects.

Associations of Age and Relationship Quality on the Relationship between Overreporting and Well-Being

Overreporting time spent face-to-face was associated with more negative affect and loneliness and this was stronger in our sample for older participants than for younger participants. This result could be interpreted in line with socioemotional selectivity theory (Carstensen et al., 1999); Older participants may enter time spent with a close other expecting it to be emotionally rewarding, making them more vulnerable to disappointment if the time felt long but not satisfying, thus amplifying negative effects. However, to draw definite conclusions, more information about what happened during the time dyads spent interacting is needed. Conflict, boredom, or type of shared activities might play into how the time that was spent was perceived as well as the unique (and potentially stressful) situation of the COVID-19 pandemic. Further, we found the same direction of interaction effects for overreporting and discrepancies in time reports. Thus, we cannot conclude that the direction of discrepancies in perceptions in the time one spends with a close other (overreporting) plays a crucial role in this association.

We did not find significant moderating effects of relationship quality on the association of overreporting and discrepancy in time reports on well-being. This could indicate that differences in time perception are more due to individual characteristics like age and not as dependent on relationship characteristics. Potentially, this could also be due to the fact that relationship quality was measured once at baseline and not at the end of each day and

thereby does not necessarily reflect the amount of support and conflict experienced within in the relationship during that day. Moreover, participants were asked to choose a close other to participate in this study, thus relationship quality was relatively high to begin with. A day with less support or more conflict than usual may have impacted how time spent together affected well-being, but we were unable to account for that.

Strengths, Limitations and Future Directions

In closing, we address some strengths and limitations of our study. We assessed time spent together in two different modalities adding to previous research. Our results on associations with well-being further highlighted the necessity to differentiate between how social encounters take place. Further, our results underline the importance of including the partner's viewpoint. Future research should investigate the origin of differences in perceptions between partners to achieve a better understanding. Limitations of our study include the sample characteristics. Our sample was predominantly white, well-educated, and healthy. The results might therefore not be generalizable to other populations. Loneliness was only measured using two items resulting in lower reliability of the measure, whereas positive and negative affect were measured with ten/nine items, respectively. Further, participants reported relatively low levels of negative affect and loneliness, even though data were collected during the COVID-19 pandemic. Moreover, social interaction time was measured using self-reports without the possibility to objectively test how much time dyads actually spent together. Therefore, overreporting reflects the difference between the time reports of the partners without verification possibilities. Knowing more about the specific activities during time spent together would allow to possibly deduct time that was not spent interacting with one another from face-to-face social interactions. This would make time spent digitally and face to-face more comparable and would further allow to understand more deeply what it is about time spent face-to-face that is beneficial for well-being, e.g. what kinds of activities are most consistently associated with well-being. Spending time together digitally offers an opportunity to make the time reports and activities more verifiable by tracking of e.g., device usage, length of calls or frequency of use (see e.g. Harari et al., 2023). Future studies should consider explicitly recruiting participants who frequently engage in time together digitally to learn how different digital activities are associated with well-being. Considering our follow-up analyses, we only measured relationship quality as support and conflict at baseline, thus being unable to account for daily variability in these measures. Future research should address the role of support and conflict on a daily basis.

Conclusion

Our findings show that more face-to-face time spent with a close other is associated with higher well-being. Time spent with a close other digitally was unrelated to well-being, which might be due to limited time spent in this modality. Overreporting the time spent with a close other did not have beneficial effects for daily well-being. More research is needed to examine whether this is due to measurement limitations (self-reported time), individual differences in time perceptions that do not necessarily vary on a daily basis, or an actual absence of an effect.

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Appendix: Supplemental Online Materials

Additional Information for the Main Analyses.

Table S1. Means, Standard deviations, and correlations.

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9
1. Age	66.14	13.75									
2. Gender	0.65	0.50	-.22**								
3. Health	3.55	0.95	.05	-.07							
4. Positive Affect	60.24	16.67	.25**	-.17**	.35**						
5. Negative Affect	17.12	14.35	-.33**	.19**	-.26**	-.56**					
6. Loneliness	12.16	16.10	-.22**	.12*	-.13*	-.44**	.69**				
7. Overreport face-to-face	83.64	98.10	.18**	-.25**	.09	.07	-.01	.07			
8. Overreport digital	20.68	65.84	-.12*	.11	-.16**	-.19**	.18**	.17**	-.07		
9. Discrepancy face-to-face	107.41	104.50	.20**	-.24**	.07	.06	-.04	.04	.87**	-.07	
10. Discrepancy digital	30.86	76.20	-.12	.04	-.20**	-.17**	.22**	.17**	-.04	.85**	-.06

Notes: *M* and *SD* are used to represent mean and standard deviation, respectively. * indicates $p < .05$. ** indicates $p < .01$. N = 276

Follow-up Analyses

Table S2. Results from multi-level models examining associations of overreporting the time spent face-to-face with one's study partner with well-being with relationship quality and age of the individual as moderators.

<i>Predictors</i>	Positive Affect		Negative Affect		Loneliness	
	<i>Estimate</i>	<i>SD</i>	<i>Estimate</i>	<i>SD</i>	<i>Estimate</i>	<i>SD</i>
<i>Support in Relationship</i>						
Intercept	60.211*	1.093	16.032*	0.915	11.469*	1.126
Support in relationship	6.033*	1.567	-5.025*	1.247	-3.527*	1.437
Overreport (between-person)	0.006	0.011	-0.002	0.009	0.010	0.010
Overreport (within-person)	0.004	0.004	-0.003	0.003	0.012	0.003
Overreport (bp) * Support	-0.005	0.015	-0.010	0.012	0.005	0.014
Overreport (wp) * Support	0.006	0.005	-0.007	0.004	0.008	0.005
<i>Conflict in Relationship</i>						
Intercept	60.181*	1.153	15.824*	0.960	11.190*	1.153
Conflict in Relationship	-2.612*	1.550	4.539*	1.221	2.498	1.437
Overreport (between-person)	0.016	0.011	-0.010	0.009	0.003	0.010
Overreport (within-person)	0.004	0.004	0.001	0.003	0.001	0.003
Overreport (bp) * Conflict	-0.010	0.013	0.006	0.010	0.008	0.012
Overreport (wp) * Conflict	-0.001	0.005	0.003	0.004	-0.006	0.004
<i>Age (individual)</i>						
Intercept	60.938*	1.120	15.227*	0.913	10.528*	1.091

Age	0.226*	0.075	-0.183	0.058	-0.070	0.067
Overreport (between-person)	0.005	0.011	-0.002	0.009	0.003	0.010
Overreport (within-person)	0.004	0.004	0.001	0.003	0.001	0.003
Overreport (bp) * Age	-0.001	0.001	0.002*	0.001	0.003*	0.001
Overreport (wp) * Age	-0.000	0.000	0.000	0.000	-0.000	0.000

Notes: $N_{individual} = 276$; $N_{dyads} = 137$; observations = 2113; $p < .05$

The number of observations and Individuals varies slightly between models due to differing patterns of missing data in the dependent/independent variables. All models are estimated based on complete cases.

Table S3. Results from multi-level models examining associations of discrepancies in the reports of how much time study partners spent together face-to-face with well-being with relationship quality and age of the individual as moderators.

<i>Predictors</i>	Positive Affect		Negative Affect		Loneliness	
	<i>Estimate</i>	<i>SD</i>	<i>Estimate</i>	<i>SD</i>	<i>Estimate</i>	<i>SD</i>
<i>Support in Relationship</i>						
Intercept	60.404*	1.054	16.238*	0.882	11.899*	1.091
Support in relationship	6.492*	1.447	-4.792	1.132	-3.469	1.325
Discrepancy (between-person)	0.006	0.010	-0.009	0.009	0.004	0.011
Discrepancy (within-person)	0.003	0.003	0.004	0.002	0.000	0.002
Discrepancy (bp) * Support	-0.003	0.013	-0.017	0.010	-0.003	0.012
Discrepancy (wp) * Support	0.005	0.004	-0.004	0.003	-0.000	0.003
<i>Conflict in Relationship</i>						
Intercept	60.787*	1.126	15.711*	0.778	11.330*	1.114
Conflict in Relationship	-3.376*	1.468	4.871*	1.136	2.625	1.357
Discrepancy (between-person)	0.017	0.011	-0.020	0.009	-0.003	0.011
Discrepancy (within-person)	0.003	0.003	0.004	0.002	-0.000	0.002
Discrepancy (bp) * Conflict	-0.021	0.012	0.012	0.009	0.015	0.011
Discrepancy (wp) * Conflict	-0.001	0.003	-0.000	0.003	-0.002	0.003
<i>Age (individual)</i>						
Intercept	61.029*	1.099	15.557*	0.892	11.100*	1.059
Age	0.248*	0.076	-0.209	0.059	-0.123	0.071

Discrepancy (between-person)	0.002	0.011	-0.002	0.009	0.005	0.011
Discrepancy (within-person)	0.003	0.002	0.004	0.002	0.001	0.002
Discrepancy (bp) * Age	-0.001	0.001	0.002	0.002	0.002	0.001
Discrepancy (wp) * Age	-0.000	0.000	-0.000	0.000	-0.000	0.000

Notes: $N_{individual} = 276$; $N_{dyads} = 137$; observations = 2113; $p < .05$

The number of observations and Individuals varies slightly between models due to differing patterns of missing data in the dependent/independent variables. All models are estimated based on complete cases.

General Discussion

First, this general discussion will address how and to what extent the research questions that guided this dissertation were answered by the three studies presented in the manuscripts, providing an overview of all results and how they fit with each respective research question. This summary of results will be followed by further considerations derived from the findings of the studies, as well as implications for healthy aging, policies, and future research directions. Finally, to conclude the discussion, the strengths and limitations of the presented research will be discussed, followed by a concise general conclusion.

Synopsis of Results

With regard to content, the main focus of this dissertation was to investigate the association of social interactions and well-being as well as loneliness in older adults' daily lives. In sum, the research questions aimed to investigate (1) how the frequency and perceived duration of social interactions are associated with elevated well-being, (2) whether frequent social interactions can buffer adverse effects of poor health on well-being and loneliness, and (3) how one's own and one's partner's perceptions of the time spent socially together affect well-being. Thus, the following sections will address to what extent the proposed research questions could be answered by the three presented manuscripts, and whether results differed across interaction modalities. Additionally, the design of the studies presented in the manuscripts offers the possibility to compare results from different time frames in ambulatory assessments of social interactions and well-being, since all three manuscripts are based off three different data sets. Further, social interactions were studied in frequency of occurrences (how often did an individual socially interact with someone else since the last measurement; Studies I and II) and perceived total social time spent with a close other during the day (Study III). Implications that can be drawn from these differences will be discussed.

Associations of Social Interaction Frequency and Duration With Well-Being

One research question that this thesis aimed to answer was how the frequency and perceived duration of social interactions throughout the day and across modalities are associated with different well-being outcomes. Overall, all three studies support the claim that a higher frequency of social interactions and a longer duration of these social interactions are associated with enhanced well-being. Enhanced well-being was characterized in all studies by an increase in positive affect and a decrease in negative affect and loneliness. The results from Study I were most consistent with this claim (Grünjes et al., 2024).

Study I assessed the weekly frequency of social interactions in four different modalities (face-to-face, video-calls, telephone calls, and text-based digital interactions) during the COVID-19 pandemic over 64 consecutive weeks. Results painted a clear picture for social interactions in the modalities face-to-face, telephone calls, and text-based digital communication: at the between-person level, a higher interaction frequency was associated with more positive affect as well as less negative affect and lower loneliness. In other words, participants who interacted more frequently face-to-face, via telephone, or through text-based digital means than other participants reported greater well-being. The same pattern emerged at the within-person level, meaning that on days when participants reported more face-to-face, telephone, or text-based digital interactions than usual, they also reported higher well-being relative to their own average.

However, we did not find a clear pattern of associations between the frequency of video-calls and well-being: there were no significant associations at the between-person level and heterogeneous associations at the within-person level. During weeks when participants reported more video-calls than usual, they reported more negative affect than usual, but also less loneliness than usual. This adds to the mixed landscape of previous findings regarding the role of digitally mediated communication for well-being (Y. K. Kim & Fingerman, 2022; Lin & Lachman, 2021, 2024; Skalačka & Pajestka, 2021). However, many earlier studies either assessed video-calls in a work setting (Beyea et al., 2025; Kang & Van Ouytsel, 2024) or aggregated different forms of digital communication modalities (e.g. summarizing emails, text-messages, and video-calls; Kim & Fingerman, 2022; Skalačka & Pajestka, 2021), thereby making it impossible to draw definite conclusions about the role of video-calls for well-being. Possibly, video-calls were too new and unfamiliar to our participants at the time of data collection, and thus beneficial effects of a “richer” interaction modality (compared to telephone calls and text-based digital interactions according to Media Richness Theory; Daft & Lengel, 1983) could not fully unfold. Being familiar and confident in using technology is an important aspect of why people adapt to new technological tools (Quan-Haase et al., 2018), and digital communication use increased during the pandemic (Nguyen et al., 2021; Tomaz et al., 2021). Further, communicating via video-calls might have been strongly associated with the pandemic itself and highlighted the limitation of in-person contact, thereby causing frustration.

It was argued before that interaction modalities such as video-calls, telephone calls, and text messages convey less information than face-to-face interactions and are thus less rich

in information (Daft & Lengel, 1983). Therefore, we hypothesized that there would be no significant effects of telephone and text-based digital modalities on the association between frequency of interaction and well-being. Since we found positive associations between higher frequency of telephone and text-based digital interactions and well-being, we conducted Chi Square analyses to compare the effects of frequent social interactions in the less rich modalities to those in face-to-face interactions. Results from these analyses showed that effects on loneliness stemming from the frequency of face-to-face interactions were significantly stronger than effects from all other three modalities at the within-person level. This suggests that in-person contact is especially important on days when older adults feel lonelier than usual and can play a crucial role in mitigating feelings of loneliness. At the between-person level, face-to-face interactions also showed significantly stronger effects on the association between frequency of interaction and negative affect compared to video-calls. This highlights that, while other modalities are beneficial, face-to-face interactions play a uniquely important role in supporting older adults' daily well-being.

Results from Study II (Grünjes et al., 2025) support the assumption that more frequent social interactions are associated with elevated well-being, though less consistently than Study I. In Study II, social interactions were measured daily in three different interaction modalities (face-to-face, telephone calls, and text-based digital messages). Results suggest that more frequent social interactions face-to-face are associated with more positive affect and less loneliness both at the between- and the within-person level. In other words, participants who reported having more frequent face-to-face interactions reported more positive affect and less loneliness than participants with less frequent face-to-face interactions. The same pattern was observed for days when participants reported more face-to-face interactions than usual: they also reported more positive affect and less loneliness than usual. Results showed no significant associations between the association of frequency of telephone calls and well-being, neither at the between- nor the within-person level. A higher frequency of text-based digital interactions was only associated with well-being at the between-person level: participants who reported more frequent text-based digital interactions than other participants reported less negative affect and less loneliness.

For Study III (Grünjes et al., submitted), participants were asked to indicate how much waking time they spent with their study partner (a close other of their choice) either face-to-face or digitally, instead of reporting social interactions in occurrences, as in Studies I and II. We found significant associations between time spent face-to-face with negative affect and

loneliness at the between-person level, indicating that participants who report to spent more time face-to-face with their study partner than other participants report less negative affect and less loneliness. Thus, these results also support the notion that more social interactions (in frequency as well as in time) are associated with elevated well-being. Nevertheless, the results in this study were less clear compared to results in the other studies. This was most likely due to greater measurement noise in the items: asking how much waking time one spent with another person might go beyond socially interacting with them and can include various other activities that we did not account for. Further, it complicates the comparison of modalities (in person vs. digital), since spending time together digitally possibly involves a higher proportion of social interaction than spending time together in person. The latter can also mean cohabiting, watching a movie, eating, or reading beside one another, whereas spending time together digitally most likely means chatting online in one form or another.

In sum, results from all three studies show that more social interactions are beneficial for well-being, and we demonstrate this across different time frames and different samples of older adults. We found the most consistent results in Study I with weekly time frames, and the least consistent results in Study III, which measured perceived social time in duration instead of the frequency of social interactions. We further found support for the idea that frequency of social interactions plays a role in different facets of well-being, since we observed different patterns of effects for positive, negative affect and loneliness. This should encourage other scholars to include a differentiated assessment of well-being and to consider assessing loneliness as well.

Buffering and Compensatory Effects of Social Interactions on Well-Being

The second research question of this dissertation aimed to investigate whether frequent social interactions in different modalities can buffer against adverse effects of poor subjective health on well-being and loneliness in older adults' daily lives. This research idea was based on the buffering hypothesis of social support (Cohen & Wills, 1985), which states that social support can protect individuals from harmful consequences of stress. According to this hypothesis, buffering can occur in two different ways. It is possible that social support weakens the negative effect that stressful events have on an individual, or that social support prevents the a stressor from significantly impairing the individual (Cohen & Wills, 1985). In other words, buffering can occur through receiving resources to help handle stressful situations or by helping to reappraise the stressor and thus mitigate the strength of its negative effect on the individual. Investigating how poor subjective health in daily life (defined as the stressor)

affects daily well-being and whether frequent social interactions can exert a buffering effect was the main focus of Study II (Grünjes et al., 2025). However, some more directions on the topic of buffering or compensating effects of social interactions can also be drawn from results of Study I (Grünjes et al., 2024).

In sum, we found evidence for potential buffering effects of social interactions on the association between poor self-rated health and health complaints in daily lives. Nevertheless, results were not as clear as expected and also did not imply that one interaction modality is especially suited to buffer against adverse effects from poor self-rated health on well-being. Rather, it appears that different modalities may be suited for different situations or individuals to varying degrees. Study II ran multi-level regression models to examine the association between daily poor self-rated health / health complaints and daily well-being and loneliness in Swiss older adults ($M_{\text{age}} = 72$ years). Buffering effects were investigated by assessing whether daily frequency of social interactions in different modalities moderated the association between self-rated health and well-being. We found different patterns of buffering effects for the modalities with regard to outcome variables and to the between- or within-person level. Effects for face-to-face interactions were only significant at the within-person level, whereas buffering effects of digital text-based interactions were only significant at the between person-level. On days when participants rated their health worse than usual, they also reported more loneliness when they reported fewer than usual face-to-face interactions compared to days with equally poor self-rated health but more than usual face-to-face interactions. This result implies that face-to-face contact might be especially beneficial as an impromptu response to having a worse-than-usual day.

Regarding digital text-based interactions, participants who reported poorer self-rated health than others but more digital text-based interactions than others reported less loneliness than participants with fewer digital text-based interactions. Moreover, participants who reported more health complaints over the course of the 21 days of the study but also more digital text-based interactions than others reported more positive affect than those with more health complaints but fewer digital text-based interactions. Thus, it might be possible that participants who have larger or more frequent digital networks perceive themselves to have more potential support available, and the sheer perceived availability of being able to contact others already serves as a buffer (Cohen & Wills, 1985). However, in acute situations of poorer-than-usual self-rated health, frequency of digital text-based interactions did not show significant moderating effects and might be less suitable compared to in-person contact.

Digital text-based interactions do not necessarily mean an immediate response, thus it might also be the case that delayed responses in more stressful situations than usual are too slow for individuals to experience a buffering effect.

Results were a little more mixed for telephone calls, however, participants in this study reported relatively less telephone calls compared to the other modalities (mean average of 0.51 telephone calls per day as opposed to 1.76 average face-to-face interactions and 1.22 digital interactions respectively), thus results from this modality must be considered with some caution. On days when participants rated their health worse than usual and also reported fewer telephone calls than usual, they reported less positive affect and more loneliness compared to days with worse health ratings but more than usual telephone calls. This implies that reaching out more to others via phone on days when one's self-rated health is lower than usual can help protect against negative effects of health on well-being that day. Further, participants who reported more health complaints than other participants over the course of the study period but more telephone calls than others reported less negative affect and less loneliness than those with more health complaints but less telephone calls.

These results from Study II highlight two important implications. First, frequent social interactions hold the potential to buffer the negative effects of poor daily health on well-being. This is an important finding, since old age is associated with decreasing health (Bhullar et al., 2010), as well as increasing loneliness (Holt-Lunstad, 2018), and decreasing social network sizes (English & Carstensen, 2014). Seeing that increasing and maintaining frequent social contact can improve well-being itself, as well as buffer the relationship between poor health and well-being, underlines the importance of staying socially connected in old age. Helping older adults maintain a strong social network, even through less rich interaction modalities such as digital text-based media, can thus be beneficial in two ways: by directly improving daily well-being and reducing loneliness, and by mitigating adverse effects of poorer health, which might inevitably be part of aging. Second, social interactions in different modalities might be better suited to provide buffering in different situations. Since we only found buffering effects for face-to-face interactions at the within-person level, one might conclude that in acute stressful situations, such as having a bad health day, in-person contact is still uniquely beneficial for well-being. However, we cannot rule out the possibility that on those days, when participants reported poorer health than usual and also more face-to-face interactions than usual, those social interactions were also accompanied by other forms of support, such as instrumental support. Previous research (Helgeson, 1993) suggests that

emotional and instrumental support might play a different role in buffering stress, thus, these effects might play a role here as well.

In addition to investigating buffering effects in Study II, we also looked at moderating, or rather compensatory, effects of frequent social interactions in weaker interaction modalities (video-calls, telephone calls, and text-based digital communications) in Study I. More precisely, we examined whether during times of stricter governmental restrictions during the COVID-19 pandemic (Grünjes et al., 2024) and limited in-person contact, beneficial effects of social interactions in weaker modalities on well-being would be stronger. Data were collected between April 2020 and June 2021, covering several seasons, which allowed us to study different phases of the pandemic that went along with varying levels of stress and social isolation. We were interested in whether effects of social interactions via video-call, telephone, or text-based digital modalities on well-being were stronger during times of stricter governmental restrictions on social contact. We found compensatory effects for a higher frequency in digital text-based social interactions: during weeks of stricter governmental COVID-19 restrictions, the positive association between a higher frequency of text-based digital interactions with well-being was stronger. In other words, the association between a higher frequency in text-based digital interactions and more positive affect, as well as less negative affect and loneliness, was stronger than during weeks with less strict governmental restrictions. Again, these results suggest that digital social interactions can be a great source of support during times of heightened stress or limited other opportunities to socialize.

Older adulthood is characterized by the need to adapt to normative life changes, e.g., in mobility or daily structure (i.e, after retirement; P. B. Baltes & M. M. Baltes, 1990), which can be accompanied by heightened stress, an increased risk of social isolation, and thus adverse effects on well-being and health. According to Baltes and Baltes' (1990) SOC Model (Selection, Optimization, and Compensation), adequately compensating for age related losses is a key factor in healthy and successful aging. Our results suggest that, even though face-to-face interactions show the most consistent associations with enhanced well-being and health, especially during times with limited face-to-face contact, digital social interactions can compensate for the lack of in-person contact. Being digitally connected and using technology to socially interact can therefore be interpreted, in light of the SOC model, as successfully compensating for situations that result in limited in-person contact. In our study, the situation was mainly caused by strict governmental restrictions implemented in response to the spread of the coronavirus. However, old age can cause similar situations (e.g. limited mobility of

individuals or of social contacts of similar age), and thus increasing digital contact could be seen as successfully adapting to normative age-related changes.

Effects of Self- and Partner Perceptions on Well-Being

Since social interactions inherently involve an interaction partner, the third research question of this dissertation addressed how both the individual and the interaction partner perceive their social interactions. Study III examined whether these perceptions were associated with well-being. Study III (Grünjes et al., submitted) used data from 137 dyads that estimated the time they spent with their study partner (a close other person of their choice) for ten consecutive days and also reported their well-being and loneliness in the evening. Consistent with the patterns observed in the two studies examining the frequency of social interactions, we found that perceiving to have spent more time with one's study partner was associated with higher well-being at the between-person level. Specifically, participants who reported spending more face-to-face time with their study partner across the study period experienced lower negative affect and less loneliness.

However, no significant associations emerged at the within-person level or for time spent digitally spent time one's study partner. The divergence between these findings and those of the previous studies may be attributable to methodological differences. In the present study, participants reported the amount of time spent with their study partner, whereas Studies I and II asked participants how often they had engaged in social interactions during the day or week. Consequently, Study III did not explicitly assess social interactions. The reported time could therefore include non-interactive moments or represent an aggregation of several social encounters, as participants provided only a daily estimate of time spent together.

Furthermore, Study III exclusively focused on time spent with the study partner; other social contacts and time spent with additional interaction partners were not assessed. This design feature distinguishes it from Studies I and II, where the identity of interaction partners was not considered in the analyses.

Despite these methodological differences, the overall direction of the findings remains comparable, although the pattern observed in Study III is less consistent and less pronounced than in the preceding studies.

The main focus of Study III was to investigate differences in perceptions of the time spent with the study partner. We proposed that perceiving to have spent more time with one's study partner than the partner perceived (meaning to overreport the time spent together) could

be associated with elevated well-being, because more social time was thought to be beneficial. However, we did not find clear support for this assumption. Most associations were not significantly different from zero. We found that participants who overreported face-to-face time with their study partner more than other participants over the course of the study reported less positive affect and more negative affect and more loneliness and thus poorer well-being. We did not find any significant association of overreporting digitally time spent and well-being. We also looked into undirected differences in perceptions of the time spent together and investigated whether discrepancies in general between partners were associated with well-being. Again, we found very few significant effects. We found that larger discrepancies in the reports of time spent face-to-face were associated with less positive affect and more negative affect and more loneliness at the between-person level. Further, larger discrepancies in digital time reports were associated with more negative affect at the between-person level. These results suggest that overestimating time spent together is not beneficial or unrelated to the individual's well-being. Potentially, convergence between interaction partners is more important in other aspects of the social interactions, such as meaningfulness or pleasantness.

Thus, another aspect one can look at when considering how a social interaction was perceived is to look at qualitative aspects of the interactions. For Study II, we conducted follow-up analyses investigating how pleasantness of social interactions in different modalities was associated with well-being and whether pleasantness of the social interaction could buffer adverse effects of poor self-rated health.

Regarding associations of pleasantness of the social interaction in different modalities, we found that pleasant face-to-face interactions were associated with more positive affect and less negative affect and less loneliness at the between- and the within-person level. Pleasant telephone interactions were associated with more positive affect and less negative affect and less loneliness at the between-person level and less negative affect at the within-person level. Pleasant digital text-based interactions were associated with more positive and less negative affect at the between-person level and less negative affect at the within-person level. In sum, these results paint a similar picture to the ones from the models examining frequency effects. This indicates that examining pleasantness does not necessarily add more information to the association between social interactions and well-being than assessing frequency; the context might be crucial.

We could not find more or more consistent buffering effects for pleasant social interactions in different modalities than for our original hypotheses, which aimed to

investigate whether frequency of social interactions in different modalities buffered adverse effects of poor self-rated health on well-being. We found a buffering effect of pleasant digital social interactions on positive affect that was in line with the buffering hypothesis: the positive effect of pleasant digital social interactions was larger on days when participants' self-rated health was worse than usual. For self-reported health complaints, there was a significant interaction for pleasantness of face-to-face interactions and positive affect at the within-person level, indicating that the pleasantness of face-to-face interactions buffered the effect of self-reported health complaints on positive affect.

However, we also found several interaction effects that are not in line with the buffering hypothesis of social support: there was a significant interaction effect of pleasantness of face-to-face interactions and self-reported health on positive affect at the between-person level, indicating that the effect of pleasantness of face-to-face interactions on positive affect was larger for participants with better self-rated health than others. Further, for health complaints, there was a significant interaction with the pleasantness of telephone calls and with the pleasantness of text-based digital interactions on loneliness at the within-person level. Both effects indicate that pleasantness of telephone and text-based interactions were related to lower loneliness at times of higher self-reported health complaints and are thus not in line with the buffering hypothesis.

Another study with the same data set found that the perceived quality of a social interactions differs depending on the modality used: in sum, telephone interactions were rated as more meaningful and text-based digital interactions were rated lower in valence compared to face-to-face interactions. Text-based digital interactions were also perceived as lower in valence, social relatedness and as less meaningful compared to telephone interactions (Hülür et al., 2023). Overall, these results emphasize the importance of examining modality-specific mechanisms to better understand how social interactions contribute to well-being in different health contexts.

Variation in Effects by Modality

All three studies support the assumption that there are differences between interaction modalities in their ability to affect well-being and loneliness in daily life. Results from Study I suggest that face-to-face interactions show the most consistent positive associations with well-being and loneliness, whereas results from Study II cannot confirm this. In Study III, we only found significant associations between time spent socially with a close other and well-being if this time was spent face-to-face compared to digitally. Contrary to what we expected based on

Media Richness Theory (Daft & Lengel, 1983) and previous literature (e.g. Sacco & Ismail, 2014; Sun et al., 2020), we did find strong support for beneficial effects of digital social interactions and telephone interactions.

In Study I, participants with a higher weekly frequency reported more positive and less negative affect and loneliness compared to participants with lower frequency in face-to-face interactions. The same pattern was found for a higher frequency of telephone calls and text-based digital interactions. Further, within-person effects showed that on days when participants reported more frequent face-to-face, telephone, and digital text-based interactions than usual, they also reported more well-being than usual (more positive affect and less negative affect and loneliness). However, chi square tests that compared the effects revealed that positive effects at the within-person level from higher frequency of face-to-face interactions for loneliness were stronger than positive effects from telephone calls and text based digital interactions, indicating that during weeks when participants were lonelier than usual, face-to-face interactions played a unique role in mitigating the feeling of loneliness. Moreover, we also found that during weeks of stronger COVID-19 restrictions and therefore limited in-person contact, positive effects of a higher frequency of text-based digital interactions on loneliness were stronger than during weeks of less strict governmental restrictions (Grünjes et al., 2024). Our results thus support the idea that even though face-to-face interactions may be uniquely well suited to enhance well-being, social interactions in other, less rich interaction modalities might be just as important. In line with ideas from Kim and Fingerma (2022), who suggested that communicating digitally may complement the benefits of daily in-person encounters and thus compensate for age-related reduction of network sizes, we could conclude from our results that being digitally connected in old age is important to maintain high well-being, especially in light of declining health (Grünjes et al., 2025) or stressful contextual factors (Grünjes et al., 2024).

Study III did not find any significant associations between time spent digitally with a study partner and well-being and loneliness. This might further support the notion of differentiating more clearly between interaction modalities: spending time digitally could include engaging on social media, texting, emailing or video-calling. Since we found different results for text-based digital interactions and video-calls in the other studies, as well as results from other studies that looked at social media use (Gaia et al., 2021; Y. K. Kim & Fingerma, 2022), assessing socially interacting “digitally” without further differentiation might be too broad and create too much noise.

There is also evidence that depending on the purpose of the social interaction, different modalities are preferred: using data from the same sample as Study II, Hülür et al. (2023) found that less rich interaction modalities like telephone calls and text-based digital messages, were more likely to be used to obtain information compared to face-to-face interactions, whereas socially more demanding interactions, like small talk or conflicts, were less likely to take place via text messages compared to richer face-to-face interactions.

Differences in Effects Across Outcome Measures

All three studies presented in this dissertation defined well-being by assessing positive and negative affect (Diener, 1984) through asking participants to rate mood describing adjectives on a scale from 0 to 100, either using the PANAS scale (Breyer & Bluemke, 2016; Watson et al., 1988) or adaptations of it. Further, high well-being was defined as experiencing low levels of loneliness, which was assessed in a similar way to affective states. Previous studies have oftentimes either looked at affective states (e.g. Lin & Lachman, 2021) or loneliness (Tomaz et al., 2021). Results from all three studies show that differentiating between affective states and loneliness gives a more nuanced picture of what aspects of well-being are affected by social interactions. Therefore, future studies should continue assessing well-being in a nuanced way.

Most of our hypotheses that we phrased for loneliness were supported: frequency of social interactions in all four modalities (face-to-face, video-calls, telephone calls, text-based digital) was associated with decreased loneliness in Study I (Grünjes et al., 2024). Further, we found compensatory effects for digital social interactions on loneliness, but not for positive or negative affect, and most buffering effects of social interactions were observed for experiencing loneliness (Grünjes et al., 2025). These results highlight the potential that social interactions offer, even in less rich interaction modalities, to mitigate feelings of loneliness and to protect individuals from feeling lonely.

When investigating well-being in future studies, one could further consider not only assessing affective states but also other aspects of well-being, such as life satisfaction (Lee, 2024), sense of purpose (Pfund et al., 2022), or arousal (Hülür et al., 2023). What kind of outcome variables are suitable may also depend on the time frame of a study: it would be interesting to investigate how participants rate their well-being immediately after a social interaction. In that case, one should consider assessing arousal or valence of the interaction (e.g. Hülür et al., 2023), which might diminish faster than more cognitive assessments of well-being, such as life satisfaction or sense of purpose. Those aspects might be interesting to

investigate on daily or weekly scales and then over a longer period of time. Previous research on the variability and stability of affective states in old age (Röcke & Brose, 2013) suggests that regulatory processes improve with age, which is associated with an age-related decrease in intraindividual variability of affective states. If this assumption holds true, examining how specific events—such as social interactions—affect well-being immediately after the interaction or later in the day could provide deeper insights into the functioning of these regulatory processes.

The primary focus of this dissertation was to investigate how social interactions influence well-being and loneliness in daily life. Accordingly, the data allowed for estimating effects on daily or weekly well-being, but did not capture the immediate effects of individual social interactions.

Implications for Future Research

The presented results offer interesting implications for future research, methodological considerations as well as impulses as to where a deeper look might be needed.

Methodological Considerations

Assessing social interactions and affective states in different time frames, as mentioned above, offers the possibility of examining the processes through which social events affect well-being. Measuring well-being immediately after an interaction might offer insights into how an affective state is influenced by a social interaction with little or no time to regulate emotions. Assessing daily or even weekly well-being offers the possibility to examine more closely how social interactions affect daily lives and fit into a grander scheme of things.

Results from Neubauer and colleagues (2020) on the memory experience gap for affective states show that this gap is less intense in old age than in younger age groups, making it possible to assess how social interactions affect well-being in older adults' daily lives with more variability in time frames than other age groups. Weekly assessments (like in Study I) offer the opportunity to follow participants' daily lives for a longer period, since it is not as invasive as assessing them several times a day or at the same time each day. Researchers who are interested in following how social determinants influence well-being over a longer period of time (e.g. several months up to a year) might do so especially well with older participants, since their memory experience is not as drastic as in younger age groups.

However, future research could also investigate affective states in an even denser time frame (as opposed to longer time frames with larger intervals) and thus look at inertia effects of social interactions on well-being. Emotional inertia is defined as the degree to which affective states persist across contexts and time (Koval & Kuppens, 2024). In other words, it could be worthwhile to examine how long affective states last after being triggered by an event, such as a social interaction. Measuring well-being immediately after a social interaction and then repeatedly in dense temporal proximity could provide insights into how intense some effects of social interactions on well-being are and whether they differ depending on the interaction modality. Two studies done by Kraemer et al. (2025) investigated how frequency of social interactions, both in-person and digitally, is associated with social desire and seeking further social contact within two days on an hourly basis. Results show that associations between social contact frequency, social desire, and affective states were denser on an hourly scale than on larger time scales, indicating that, depending on what one wants to study, different time scales may be more appropriate.

The presented studies in this dissertation measured social interactions in two different ways: Studies I and II asked for the frequency of social interactions in different modalities since the previous measuring time point. Study III asked participants to estimate the time spent socially with a close other of their choice in hours and minutes. Results were clearer and more consistently in line with our hypotheses, previous literature (e.g. H. H. Kim & Jung, 2021; Skałacka & Pajestka, 2021; Tomaz et al., 2021), and theories (Daft & Lengel, 1983) in Studies I and II, where we measured frequency of social interactions. As argued in Study III (Grünjes et al., submitted), measuring perceived time might include too much noise that can influence a) how long a duration is perceived and b) how the quality of this time is perceived, and therefore impact how the social time or social interaction is associated with well-being. Droit-Volet and Wearden (2015) state that the experience of passage of time is related to affective states and depending on one's mood one perceives time to pass more slowly or faster. Thus, the direction of the effect might be the other way around and predictor and outcome variables are not independent enough from one another. Further, affective states also influence how time is assessed retrospectively at the time of assessment (Droit-Volet & Wearden, 2015). Moreover, since participants were only asked to indicate the time they spent with their study partner, it is impossible to know how that time was spent. Potentially, the variable measured companionship (Lüscher et al., 2022) rather than social interactions. However, even companionship showed associations with enhanced well-being, suggesting that estimated or perceived time might be the bigger issue in assessments. To conclude, future

studies should rely on measuring social interactions in terms of frequency or occurrences rather than in estimated duration.

Another factor to consider is whether the direction of effects of social interactions on well-being could also be reversed. Social interactions, in frequency and quality, affect well-being (Lin & Lachman, 2024; Skalačka & Pajestka, 2021; Sun et al., 2020), but affective states may also influence the frequency of social interactions. For example, Hall et al., (2022) studied whether sense of belonging and loneliness influenced the frequency with which participants sought social contact in different modalities and whether those interactions sufficiently satisfied the need to belong. They found that experiencing a low sense of belonging was not consistently associated with an increased frequency of social contact. Overall, this underlines the need to consider bidirectional processes when studying the link between social interactions and well-being. Roos and colleagues (2024) investigated in two large German life span samples how current social desire predicted seeking social interaction and whether increased social desire predicted the frequency of subsequent social interactions. They found that current social desire predicted subsequent social interactions within, but not across days. This again shows that some dynamics might only unfold and be detectible on dense time scales (adding to the previous point of considering different time scales for various research questions), but also shows that the direction of effect could be reversed and this dynamic should be studied as well. In follow-up analyses in study I (Grünjes et al., 2024) we assessed cross-lagged associations of affective states in the previous week and frequency of social interactions in different modalities in the following week. We found that higher levels of positive affect in the previous week were associated with a higher frequency of face-to-face interactions in the following week and that higher levels of negative affect and loneliness in the previous week were associated with lower frequency of face-to-face interactions in the following week. Higher levels of loneliness in the previous week were also associated with a lower frequency of text-based digital interactions in the following week, whereas higher levels of negative affect in the previous week were associated with a higher frequency of video-calls in the following week. These results point in the direction that low levels of well-being do not lead to more social interactions (which could enhance well-being) but might be more of an inhibition, possibly creating a vicious cycle. Thus, one could conclude that it is especially important to reach out to older adults in one's social circle without waiting for them to reach out first, since higher levels of loneliness might inhibit them from searching for social contact. These implications will be discussed in more detail in the next section focusing on implications from the studies' results for healthy aging. Taken together, these results

emphasize the need to further research directional processes in the relationship between social interactions and well-being. Nevertheless, they also suggest that social interactions are a more reliable predictor of well-being than well-being is of seeking out and increasing the frequency of social interactions.

Conceptual Considerations

When measuring social interactions, it is not only possible to differentiate between interaction modalities, as presented in the manuscripts that make up this dissertation. It is also possible to focus on factors like the relationship with the interaction partner, quality and pleasantness of the social interaction, or content and purpose of the interaction. As mentioned earlier, previous research found associations of interaction purpose and chosen interaction modality, as well as associations with perceived quality of interactions depending on purpose and modality (Hülür et al., 2023). A next step could be to study how these factors are related to well-being, both immediately after an interaction and in a daily context. Future research could examine which aspects of social interactions have the strongest effect on well-being. This includes questions about whether the purpose, the modality, or the interaction partner plays the most important role for older adults' well-being and health. In addition, potential age differences and differences in computer and media proficiency could be addressed.

Study III also incorporated the partner's perspective on the perceived time that study partners spent together. Our hypotheses on how differences in the perception of time between the partners affected well-being could not be confirmed. We argue that this could be due to individual differences in time perception, as well as the reasons listed in the section above that play into how long social time is perceived. Future research that is interested in differences in partner perspectives should therefore consider different approaches. One possibility would be to focus in differences in perceptions of the quality or purpose of an interaction. Previous research (e.g. Hülür et al., 2023; Kafetsios et al., 2017) found that quality and purpose of social interactions differ depending on interaction modality used, which might in turn be associated with well-being. Being congruent with one's interaction partner in terms of the perceived quality or reason for the interaction might play a crucial role in how the interaction is perceived in hindsight and whether the individual is satisfied with the encounter. Another aspect to consider could be focusing on outcome variables that are associated with the relationship of the studied dyad, as opposed to outcome variables that are associated with the individual's assessment. For example, one could study how differences in perception of social interactions or time spent together (whether it is in quality, duration, or purpose) are

associated with aspects such as relationship quality or potential conflicts in the dyad's relationship.

Circling back to theories introduced in the introduction, like Multi Modal Connectedness (Chan, 2015) and Media Multiplexity Theory (Haythornthwaite, 2001), further research is needed to investigate how associations between interaction modalities and well-being, health, and loneliness are shaped by other factors, such as the relation to the interaction partner or the purpose of the interaction. Multi Modal Connectedness suggests that interacting regularly in more than one modality is beneficial for well-being, with effects becoming evident in middle- and older adulthood (Chan, 2015). Since our results show that well-being is enhanced by a higher frequency of social interactions across various modalities, and not only face-to-face, it could be interesting to further investigate the concept of diverse communication patterns. One idea could be to calculate an index that indicates whether a person has a diverse pattern of communicating -meaning they regularly interact via various interaction modalities rather than relying mainly on one -and to examine whether expanding to more interaction modalities in daily life is beneficial for social network strength, well-being or the mitigation of loneliness. One idea could be to adapt a diversity index that has been proposed in other areas, such as stress and daily activities (Koffer et al., 2016; Lee et al., 2016), to the social interaction context. Diversity could be estimated in more than one way since social interactions do not only differ in modalities but also in interaction partners, thus several indices could be used to estimate an average diversity in communication patterns (.g. diversity in used modalities or in interaction partners). Focusing on Haythornthwaite's (2001) Media Multiplexity Theory, which proposes that any communication modality can foster close emotional bonds, future research could further investigate how the relationship with the interaction partner and the choice of interaction modality are connected. It would also be relevant to examine whether the level of closeness in the relationship or the modality used for interaction plays a more important role in affecting well-being in daily life.

Implications for Healthy Aging

Firstly, results of the presented studies highlight the importance that social connectedness in general has for well-being and health in older adults' daily lives, and they also emphasize the potential that digital communication technologies can have for older adults' well-being and health. Our results imply that digital networks and social interactions can be a source of social support for older adults to cope with environmental changes, such as decreasing networks and more time alone (e.g., enforced by governmental restrictions due to the COVID-19 pandemic;

Grünjes et al., 2024), or declining subjective health and increasing health complaints in daily life (Grünjes et al., 2025). Thus, it is important to improve older adults' access to digital communication technology and to close the digital divide.

As mentioned in the introduction, the digital divide refers to inequalities in access to as well as use of digital media and the internet depending on socio-demographics, with age being a key factor (Hargittai, 2003; Hunsaker & Hargittai, 2018). Thus, as a society, it should be a priority to increase internet access and use among older adults. At the same time, it should be a priority to invest in ways to enable and encourage older adults to use technology and to feel comfortable doing so, since feeling confident and skilled enough to use technology is a major reason why older adults engage in or disengage from technology usage (Quan Haase et al., 2018). Differences in digital skills and comfort with use might stem from previous exposure to technology (e.g. at work) and differences in socioeconomic backgrounds (Ruiz-Figueroa et al., 2025). However, once online, older adults do not necessarily stay online (König & Seifert, 2020), which urges technology designers as well as policy makers to think of ways to enhance and ease use and uptake of technology.

Many technological devices are designed or have default settings intended for younger people or people without impairments, meaning that devices have small screens and small fonts that are hard to read for people with visual impairments, and sensitive touch screens that are hard to operate for people whose fine motor skills are weakened. This leads to two major points: first, technological devices as well as applications should be designed to meet older adults' needs and abilities. This might be especially important in the sector of eHealth applications (Mace et al., 2022), but it does not stop there. It should be considered to involve older adults in developing and designing these tools and applications to get a better understanding of their needs. Second, policy makers should develop a strategy to improve technological and internet access in older age groups, as well as low-threshold opportunities to improve and train digital literacy. Research shows that even short, self-directed online courses can improve older adults' digital literacy (Moore & Hancock, 2022) and, for example, public libraries can play a crucial role in providing spaces and infrastructure to offer interventions or courses (Barrie et al., 2021). Results from various studies suggest that personal relationships, mostly with younger relatives like children and grandchildren, are key motivators and initiators for older adults to take up digital communication (Jung et al., 2017; Zosh et al., 2022). Benefitting from digital (health) applications thus often relies on social support in navigating the applications and devices (Kampmeijer et al., 2016), which makes

more digitally experienced social contacts potential gatekeepers and further deepens the digital divide.

Having access to help and assistance in navigating new technologies for communication has been shown to be a crucial factor in experiencing digitally mediated interactions as useful and beneficial (Ruiz-Figueroa et al., 2025). Especially older adults seem to experience closeness when communicating with family members digitally (compared to younger age groups), but feeling comfortable when using these technologies for communication is a crucial factor for their positive effects to unfold (Seifert, 2025). Policymakers should therefore prioritize narrowing the digital divide and establishing digital literacy without relying solely on family members and friends. Other structures and outlets need to be established.

These implications can also be interpreted in light of the Socioemotional Selectivity Theory (SST; Carstensen et al., 1999), which claims that when people have a limited time perspective, they prioritize short-term goals such as emotionally pleasant social interactions or social connectedness. According to the theory, people are less inclined to engage in risky behaviors that could lead to emotionally upsetting outcomes and are less willing to invest time in activities that may only be rewarding in the distant future or whose outcomes are uncertain. One could argue that engaging in new interaction modalities with which one is unfamiliar could be seen as risky and potentially costly if individuals are unaware of their potential benefits. Investing time and effort into learning to communicate digitally with others effectively should therefore be regarded as a promising investment, as it can facilitate emotionally rewarding outcomes in the short term, as we have shown in our studies (Grünjes et al., 2024, 2025, submitted). Accordingly, researchers as well as political and societal stakeholders should emphasize the benefits and potential of digitally mediated social contact for well-being and health, particularly among older adults. To this end, practical implementation could focus on developing accessible and easy-to-understand interventions that help older adults gain confidence in using digital communication tools and devices (see e.g., Moore & Hancock, 2022, for a successful example of digital literacy training). Furthermore, information about available training opportunities and the benefits of digital social engagement should be widely disseminated to ensure participation across diverse groups of older adults.

There are concerns, expressed for examples in the “social displacement” theory (e.g. in Kraut et al., 1998), that an increased use of social media or digital interactions may replace

time that individuals spend engaging in person with others and that, as a result, well-being and health may decline (Hall & Liu, 2022). However, results from all our studies do not support this claim. Firstly, in all our studies - even the two studies that collected data during the COVID-19 pandemic, when people were encouraged by the World Health Organization (World Health Organization, 2020) and their respective governments to minimize social contact - all our participants still had regular face-to-face interactions. It appears that, in line with previous research (e.g. Hall & Liu, 2022), digital interactions do not replace but complement face-to-face interactions (Grünjes et al., 2024; Y. K. Kim & Fingerman, 2022). Additionally, and contrary to the negative view of the social displacement theory on digital interactions, in times of limited face-to-face contact, digital interactions can compensate for the lack of in-person interactions.

Strengths and Limitations

Many of the strengths of the manuscripts presented in this dissertation have already been discussed in previous sections. However, they will be summarized and highlighted in the following paragraphs to provide a coherent overview.

First, the results presented in this discussion, which aim to answer the proposed research questions are based on three rich datasets. All three data sets used ambulatory assessment methods, enabling us to capture associations between social interactions and well-being in real time. Study II uses daily diary data from 118 Swiss older adults ($M_{\text{age}} = 72$ years) collected over 21 consecutive days. Study I uses data from a subsample of these participants ($N = 98$, $M_{\text{age}} = 72$ years) and collected data weekly over a span of 64 weeks. Study III collected data from 137 dyads who provided data over 10 consecutive days ($M_{\text{age}} = 66$ years). These designs allowed us to study the role of social interactions in older adults' well-being across different time frames and during different periods (pre- and during the COVID-19 pandemic). Furthermore, the micro-longitudinal design of our studies made it possible to analyze between- and within-person as well as cross-lagged effects. These analyses provide a richer picture of how and when social interactions across different modalities can be beneficial for well-being in older adults' daily lives.

Well-being was also measured through three different outcome variables, focusing on positive and negative affect as well as loneliness. Our results highlight that associations between social interactions across modalities differ for positive and affect and loneliness, emphasizing the importance of studying all three aspects in daily life.

Furthermore, we investigated effects across various interaction modalities in our studies, which enabled us to detect different patterns of associations between modalities and well-being outcomes. Since we found differing associations between interaction modalities and well-being, future studies should also incorporate differentiated measures to identify the mechanisms through which social interactions in different modalities influence well-being. Moreover, few other studies have provided such a detailed differentiation between interaction modalities as Studies I and II when investigating their role in the relationship between social interactions and well-being among older adults.

All three studies incorporated health as a covariate or, in the case of Study II, as a predictor. Including health in studies on older adults' well-being is crucial, since old age is often characterized by declines in health (Bhullar et al., 2010) and health in turn is associated with well-being in daily life (Potter et al., 2022; Schöllgen et al., 2016). Across all studies, self-rated health was significantly associated with well-being.

In Study III, we further included the partner's perspective on the association between social interactions and well-being.

Regarding limitations, even though the manuscripts presented in this dissertation are based on three different data sets, all participants were predominantly White, well-educated, in good health and lived in wealthy, Western countries (Switzerland and Canada). Using digital communication technologies was a participation requirement (in Studies I and II): therefore it is questionable to what extent our results are generalizable to a broader population that may not meet these criteria or be as familiar with digital technologies as our participants were. On the other hand, this opens opportunities to plan and conduct intervention studies, that test our design with participants who are strategically taught how to use and connect with others digitally. Additionally, recruitment of participants followed the principle of volunteering: participants could opt out of the study at any time without consequences and enrolled on a voluntary basis.

Moreover, two out of the three data sets were collected during the COVID-19 pandemic. Although this provided a unique opportunity to study non-in-person social interactions more closely and in greater depth, it also means that participants were assessed during a stressful and exceptional period, limiting generalizability of the effects to post pandemic behavior and effects. Advantages that arose during the pandemic, such as increased use of digital technologies to interact with others (Tomaz et al., 2021) may not have persisted

in daily life afterward (König & Seifert, 2020). Nevertheless, even during the COVID-19 pandemic, participants in all samples reported many face-to-face interactions and relatively low levels of negative affect and loneliness and high levels of positive affect indicating that the pandemic might not have hit them as severely as imagined. These findings underline the importance of interpreting pandemic-related results with caution. However, they also emphasize that, even under restrictive conditions such as the COVID-19 pandemic, older adults were able to maintain social contact, highlighting older adults' adaptive capacities to new and challenging circumstances.

As for the measures used in our studies, they all relied on self-report. Further, the instruments used for well-being outcomes and loneliness (Macdonald & Hülür, 2021; Watson et al., 1988) were developed to assess between-person effects (Brose et al., 2020), yet we also used them to examine within-person effects. Reliability measures were mostly acceptable to very good for within-person effects; however, some of the measures for loneliness were not. This might also be due to the fact that loneliness was usually assessed with fewer items than affective states. Health in Study II was assessed using only two self-report items. In general, when measuring social interactions, we assessed only modality and frequency/perceived duration during the day and did not include aspects such as interaction partner, purpose or other social factors that were salient during the day of assessment.

Conclusion

The overall aim of this dissertation was to investigate the role of social interactions across different modalities for well-being and health among older adults' daily lives. In sum, findings from the three studies embedded in this dissertation show that a higher frequency of social interactions and a longer estimated duration are associated with enhanced well-being across modalities. Further, results suggest that social interactions can buffer adverse effects of poor health on daily well-being. Congruence with one's partner in perceived duration of an interaction does not seem to have the assumed effects on the individual's well-being, thus, studying partner effects in the association between social interactions and well-being should focus on a different aspect of evaluation.

Overall, beneficial effects of social interactions for well-being have been shown across interaction modalities. Even though, face-to-face interactions still showed to some degree the most consistent and strongest effects in the association between social interactions, well-being, and health, results suggest promising beneficial effects of digital interactions. This seems to be especially important in contexts of limited in-person contact or declining health.

Thus, it should be a priority for political and societal stakeholders to mitigate the digital divide and improve older adults' access to digital and online communication tools.

In sum, older adults and their social networks are well-advised to incorporate digital communication modalities into their daily lives, since they seem to be beneficial for well-being, but might also compensate for lack of face-to-face contact and buffer against adverse effects of poor self-rated health in daily life.

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