



Mode of social contact is associated with momentary verbal communication of emotion and well-being in older adults



Shiyang Zhang ¹✉, Sibo Gao ² & Karen L. Fingerman ^{2,3}✉

Older adults prioritize emotional well-being in their relationships, but communication of emotion may differ during in-person and phone contact. Older adults ($N = 266$, aged 65-90) completed ecological momentary assessments (EMA; $n = 4,627$) reporting their social encounters via different modes of social contact and positive and negative mood every 3 hours. Participants wore a device with the Electronically Activated Recorder (EAR) app which recorded 30 seconds every 7 minutes ($n = 104,746$ sound files). Linguistic Inquiry and Word Count (LIWC) extracted linguistic features reflecting verbal communication of emotion from the sound file transcriptions. Multilevel models revealed that in-person and phone contact were associated with communicating more positive emotions, and in-person contact was associated with communicating more negative emotions. There was no statistically significant evidence that the association between communicating positive emotions and more positive and less negative mood varied by form of communication. Participants who had less in-person contact on average experienced a greater increase in positive mood when they communicated positive emotions. This study emphasizes the emotional benefits of social contact, particularly for communicating positive feelings. Findings highlight the role of in-person contact in older adults' daily lives, allowing for the verbal communication of negative emotions.

Communicating emotions to social partners is an essential feature of relationship functioning with complex associations with social contact, emotion regulation, and emotional well-being^{1,2}. Communicating emotions and maintaining emotional connections with social partners are especially important for individuals in later adulthood, a life stage where people prioritize emotional needs and high-quality relationships with social partners (e.g., spouse, children, friends)³. Notably, due to the various types of verbal and non-verbal cues that are available during social contact, the mode of social contact (in person or by phone) may influence how often older adults express emotions in their speech and the resulting emotional benefits derived from social contact^{4,5}.

Studies examining different modes of contact in a daily context among older adults consistently highlight benefits of in-person contact^{6,7}. The current study aims to provide a more fine-grained analysis of the emotional influences of different modes of contact, by focusing on individuals' frequency and benefit of verbal communication of emotions during in-person and phone contact. Indeed, from an interpersonal emotion regulation perspective, individuals may share positive emotions to maintain or to

amplify positive feelings and disclose negative feelings as an outlet or relief that also promotes emotional well-being^{8,9}. Different modes of social contact may serve as venues for verbal communication of different emotions and potentially provide different emotional benefits.

We examined the following research questions: (a) Are the associations between in-person contact as well as phone contact and communication of emotions the same? (b) Do older adults show benefits in daily mood from expressing both positive and negative emotions? and (c) Are the emotional benefits from verbal communication of emotions the same across different modes of social contact (in-person, phone)? This study does not consider texting, social media, or video communication because estimates suggest that fewer than two thirds of adults over the age of 70 may own a smartphone and just over half use social media^{10,11}. The current study examines older adults' social experiences and verbal emotional expression in an ecologically valid setting. We draw on a dataset of naturally occurring speech among older adults collected over multiple days, and do so in combination with self-reports of social contact and mood throughout the day.

¹Population Research Center, The University of Texas at Austin, Austin, TX, USA. ²Department of Human Development and Family Sciences, The University of Texas at Austin, Austin, TX, USA. ³Center on Aging & Population Sciences, The University of Texas at Austin, Austin, TX, USA.

✉ e-mail: shiyang.zhang@utexas.edu; kfingerman@austin.utexas.edu

Different modes of social contact may differ in opportunities to share different information or topics. Specifically, media richness theory and research with young adults suggests that in-person contact carries a larger amount of information, including both verbal and non-verbal cues (e.g., physical contact, eye contact, facial expression) than does phone contact^{4,12}. Nonverbal cues may facilitate emotional connection and be associated with conversations where individuals share thoughts, feelings, and experiences at a personal level¹³. For example, one study followed 102 couples for a week and found physical touch to be associated with intimacy and better well-being for the actor and recipient of the touch¹⁴. This study shows the critical role of non-verbal cues and in-person contact for effective communication of emotions. Such findings suggest that compared to phone contact, individuals may find it easier and more comfortable to express emotions during in-person contact. In sum, the availability of cues (e.g., facial expression), during in-person contact may enhance interpersonal recognition of positive and negative emotions (e.g., fear, happiness, disgust)¹⁵. Verbal communication of emotion may reflect the enhanced opportunities for a range of communication available in person.

Additionally, accessing various types of informational cues during in-person contact may allow individuals to understand social partners' emotions better and faster and thus be able to provide and receive synchronous feedback¹³. These processes may be evident in the verbal content individuals use to express or describe their emotional experiences. In contrast, phone contact may restrict the source of information to verbal cues only and impede emotion recognition and communication in a timely manner. A 14 day diary study of young adults found that receiving responses from close social partners was important for expression of emotion in that interpersonal context¹⁶. As such, in-person contact may provide a rich set of informational cues that are important in emotion recognition and communication. These cues may further support disclosing emotions, sharing personal thoughts, and providing compassionate feedback. In sum, older adults may be more likely to communicate their positive and negative emotions during in-person contact, compared to phone contact (H1).

Individuals often engage in social interactions to regulate emotions, a process known as interpersonal emotion regulation (IER)². Based on the IER framework, engaging in interpersonal communication and social sharing may have intraindividual consequences on individuals' mood^{1,17}. For example, studies using diary approaches and laboratory manipulations revealed that when young adults express positive emotions and share positive events, social partners may provide encouraging responses that verify individuals' initial pleasure and thus boost their original positive emotions¹⁸.

On the other hand, the emotional outcomes of sharing negative emotions may be more complex, with studies yielding contradictory findings. Some studies found that verbal communication of negative emotions was associated with worse mood. For example, a study with 49 married couples found higher usage of more negative emotion words to be associated with higher cardiovascular reactivity, suggesting more intense emotional experiences and heightened physiological arousal¹⁹. Another line of research suggests that sharing negative emotions and events may help individuals relieve emotional burdens, potentially leading to an improved mood. For example, one study tracked college student participants' emotions and social sharing of emotions for five consecutive days. The study found that participants experienced shorter duration of negative emotions (anger, fear, sadness) if they shared the emotion with social partners²⁰. Another study tracked interactions in romantic couples for a week and found that spouses reported worse emotional well-being on days when they were encouraged to suppress their emotions²¹. Although communicating negative emotions may involve rumination and revisiting the negative experiences, we draw on the literature suggesting that sharing negative feelings with social partners facilitates the receipt of social support and improves individuals' emotional well-being²². We hypothesized that communicating both positive and negative emotions to social partners may be associated with better mood throughout the day (H2).

However, different modes of contact may come with varied levels of emotional information and social engagement, which may further influence how people express their own emotions and how much they benefit from expressing emotions. The Interpersonal Model of Capitalization describes the interpersonal emotion-sharing process and intra- and inter-personal outcomes^{1,23}. Specifically, receiving attentive and empathetic responses may maximize emotional benefits and contribute to sustained positive mood. For instance, in a study where young adults shared positive events with peers in online forums, receiving positive social feedback enhanced their social bonding²⁴. In the context of sharing negative emotions, participants subjectively reported feeling better when a partner listened to them express negative emotional reactions, but only experienced emotional recovery from negative videos when social partners responded with cognitive reappraisal²⁵. Similarly, participants reported reduced anxiety after being provided with good support (e.g., social partners maintained eye contact, validated participants' emotions, and gave comforting responses) but not after poor support (e.g., social partners appeared distracted, reduced eye contact, and disconfirmed participants situation)²⁶. Together, these studies highlight the subjective value of expressing emotion, and the importance of receiving specific forms of supportive feedback from social partners.

Importantly, in-person contact provides individuals with visual and context cues along with verbal cues, thus enhancing opportunities for emotional feedback and leading to better communications of emotions⁴. On the other hand, people may be less likely to express emotions and more likely to ignore other people's emotions on the phone and fail to provide encouraging responses. Not being able to recognize and acknowledge social partners' emotions may lead to decreased emotional well-being for individuals who express emotions. For example, a daily diary study found that individuals reported worse mood on days when their romantic partners ignored their emotions²¹. Despite the limited research directly comparing social partners' response style and quality of responses between modes of contact, in-person contact may provide greater opportunities for verbal and non-verbal cues that facilitate active and high-quality responses. As such, we expect mode of contact to moderate the associations between verbal communication of emotion and better mood. The associations would be stronger for communication of emotions during in-person contact, compared to phone contact (H3).

This study also controlled other factors associated with emotional expression via different modes of contact and well-being as covariates: gender, age, marital status, education, ethnicity and race, health, social network size, and time of the survey (morning, afternoon, evening). A comparison of men and women of different ages revealed that women are more likely to actively express emotions and seek support when they experience negative emotions than are men; findings suggest gender differences may be likely in verbal expression of emotion²⁷. Life satisfaction may vary by age in adulthood, with some studies finding older adults report more life satisfaction and others finding decreased life satisfaction^{28,29}. Older adults who are married report better well-being and have better health compared to those who are unmarried³⁰. Individuals with better education are more likely to have better well-being in late adulthood³¹. Race and ethnicity may contribute to subjective well-being among older adults³². Self-rated health is associated with indicators of social connectedness cross-sectionally³³. Circadian rhythm may impact individuals' social contact and mood. Individuals may be more likely to socialize in the evening and tend to show a better mood in the morning³⁴.

Hypotheses were as follows:

H1: Older adults would be more likely to engage in verbal communication of positive and negative emotions during in-person contact, compared to phone contact.

H2: Verbal communication of both positive and negative emotions would be associated with more positive mood and less negative mood in the same 3 hours.

H3: Mode of contact would moderate the associations between emotional expression of positive and negative emotions and mood, and such

associations would be stronger during in-person contact compared to phone contact.

Methods

Samples and Procedures

This study drew on data from *The Daily Experiences and Well-being Study* (DEWS). The study was pre-registered (<https://doi.org/10.17605/OSF.IO/FM3AS>) on April 30, 2024 with specific hypotheses and analytic strategies used in the current study included. This study was conducted in compliance with the University of Texas at Austin Human Subjects Board. Participants signed informed consent documents prior to the start of the study. Participants first completed a 2-h initial interview for which they received \$50. Then, they completed Ecological Momentary Assessments (EMA) in which they reported social contact on an Android device every 3 h during waking hours for 5 to 6 days, for which they received \$100 to compensate for their time. An Electronically Activated Recorder (EAR) app was installed on the Android device to unobtrusively record ambient sounds. The EAR was activated for 30 s every 7 min throughout the day³⁵.

Of the 333 older adults who completed the initial interview, 22 participants did not participate in EMA or did not complete more than five EMA assessments, and an additional 27 participants did not have valid EAR data and were excluded from the current study. We also excluded 18 participants with sound files in Spanish that resulted in different linguistic feature analysis. As such, the current analytic sample included 266 participants. Compared to the preregistration where the sample size was 286, we further excluded 20 participants ($n = 2$ did not have more than five EMA, $n = 18$ only had sound files in Spanish). Supplementary Fig. 1 summarizes the data collection procedures. Data collection was conducted in the greater Austin area in 2016–2017.

Compared to the participants who did not complete the EMA and/or EAR ($n = 67$), participants eligible for the current study ($n = 266$) had a higher score of self-rated health ($t(331) = 2.88$, $p = .004$, Cohen's $d = 0.46$, 95% CI = [-0.77, -0.15]), were less likely to identify as racial or ethnic minorities ($\chi^2 = 44.22$, $p < .001$, Cramer's $V = 0.37$, OR = 0.12 (95% CI = [0.05, 0.25])), and reported higher educational level ($\chi^2 = 9.45$, $p = .009$, Cramer's $V = 0.17$, 95% CI = [0.05, 0.30]). No statistically significant differences were detected between the eligible and excluded samples in age, gender, and marital status. We obtained 104,746 sound snippets, one of the largest known collection of sound files from older adult samples, which were then mapped to 4,627 3-hour EMAs. This resulted in 22.64 sound snippets per 3-hour assessment on average ($SD = 3.43$), among which participants spoke during 21% of the snippets. The percentage of speaking snippets was consistent with previous EAR studies that tracked participants' ambient sound in daily lives (e.g., 24%)³⁶.

Baseline Interview Measures

Using the social convoy framework³⁷, participants named people who were close and important to them in three concentric circles. This measure is widely used with adults of all ages. Participants listed 15.49 close social partners on average ($SD = 6.91$, range = 0–30).

Participants reported their age in years and gender as 1 (*women*) and 0 (*men*). Marital status was reported as married/remarried, cohabiting, widowed, divorced, never married and was recoded 1 (*married or cohabitating*) and 0 (*not married*). We recoded educational attainment as 1 (*high school or less*), 2 (*some college school*), and 3 (*college or more*). Corresponding dummy variables were generated for each education level. Participants reported their race and ethnicity, recoded as 1 (*ethnic or racial minority*) and 0 (*non-Hispanic White*). Participants rated their health on a scale from 1 (*poor*) to 5 (*excellent*)³⁸.

Ecological Momentary Assessment (EMA) Measures

We transferred the top ten social partners listed in the baseline survey to the EMA surveys. At each 3 hour EMA assessment, participants indicated whether they had contact with each of their ten closest social partners. They also reported whether they had social contact with up to six additional social

partners. If participants indicated an encounter, they reported the mode of social contact (in-person, by phone, or by text/email/social media). We calculated the number of in-person and phone contact in the 3-hour intervals respectively. Additionally, for further analyses, we generated variables indicating if each 3-hour assessment contained (a) in-person contact only, (b) phone contact only, (c) both in person and phone; and (d) neither.

This study did not include an analysis of verbal communication of emotion through digital social contact (text/email/social media) for two main reasons. First, we focused on participants' spoken language (details in the following section) and we did not have access to participants' written digital communication for analysis. Second, a significant proportion of adults over the age of 65+ do not own a smartphone¹⁰, and digital contact was relatively rare among older adult participants during the study period. On average, participants reported 0.28 digital contact during the 3-hour intervals ($SD = 0.81$).

Participants rated the extent to which they felt four positive (e.g., calm, content) and five negative (e.g., irritated, sad) emotions from 1 (*not at all*) to 5 (*a great deal*) every 3 hours throughout the day^{39,40}. Average scores were calculated for positive (Cronbach's $\alpha = .69$; ICC = .75) and negative (Cronbach's $\alpha = .72$; ICC = .54) mood respectively.

Dummy variables were generated to indicate if the assessment happened in the (a) morning (6am to 11:59am), (b) afternoon (noon to 6:59 pm) and (c) evening and bedtime (7 pm to 5:59am).

Electronically Activated Recorder (EAR) Recording of Positive and Negative Emotions

The current study used the Electronically Activated Recorder (EAR) to unobtrusively capture authentic, real-world interactions by intermittently recording ambient sounds. By collecting sound data in participants' natural settings, the EAR is an ecologically valid method that enhances understanding of older adults' social contact and communication in a daily context³⁵. The EAR in the current study was activated for 30 seconds every seven minutes during waking hours throughout the day³⁵. Trained research assistants transcribed participants' speeches verbatim. Social partners' speeches were not transcribed due to ethical considerations. Each file was transcribed by two different assistants and meetings were held to reach consistency if different transcriptions emerged.

The transcriptions were then entered into the Linguistic Inquiry and Word Count 2015 (LIWC)⁴¹. LIWC is a widely used and validated text analysis tool that can provide information on individuals' language use in expressing emotions^{42–44}. LIWC uses a word frequency approach and compares text corpus with an embedded dictionary to infer emotional state from verbal behaviors. The positive emotion dictionary contains 620 words (e.g., happy, love, sweet) and the negative emotion dictionary contains 744 words (e.g., frustrated, hurt, ugly)⁴¹. LIWC compared transcribed sound snippets with its embedded dictionary to generate positive and negative emotion scores, which quantifies the extent to which participants expressed emotions during daily social contact. The score for each category reflects the percentage of targeted words relative to the total word count. For example, the positive emotion score of a given snippet is calculated by dividing the number of positive emotional words (defined by LIWC dictionary) by the total number of words in the snippet. Higher scores indicate a greater frequency of words related to either positive or negative emotions, reflecting higher levels of verbal communication of emotion during social contact. Sound snippets in which participants did not speak corresponded to a score equaled zero for communication of emotions. The scores of expressing emotions were measured 30 seconds out of every 7 minutes and were then aggregated into the 3-hour assessment level (by calculating the average scores) to match EMAs.

Analytic Strategy

First, we examined descriptive statistics and bivariate associations between the key variables. To test the hypotheses, we estimated a series of multilevel models with 3-hour assessments (*level 1*) nested within participants (*level 2*).

We considered using three-level models with assessments nested within days nested within participants, but three-level models yielded the same pattern as two-level models, such that participants reported more positive mood during in-person and phone contact, yet more negative mood only during in-person contact. We omitted results from the three-level models for parsimony. We separated time-varying predictors (i.e., variables on the three-hour assessment level) into person-mean centered variables and person means, in order to isolate the within-person association (i.e., intrapersonal fluctuations within the study period) from the between-person association (i.e., interpersonal differences between participants). All models considered the time of the day (morning, afternoon, evening; assessment level) and participant level age, gender, marital status, racial and ethnic minority status, education, self-rated health, and social network size. All analyses were performed in Stata 17.

We estimated multilevel models to test the associations between mode of contact and verbal communication of emotions (H1). The time-varying predictors were the numbers of in-person and phone contact that participants had during the prior 3 hours. Two separate models were estimated for communication of positive and negative emotions respectively. Random slopes of in-person and phone contact were included in both models.

We then examined the associations between verbal communication of emotions and mood (H2) by estimating multilevel models with communication of positive and negative emotions (LIWC scores) as the time-varying predictors. Communication of positive and negative emotions were entered into the same model to examine their links to mood cohesively. The outcomes were positive and negative mood in two separate models. Random slopes of communication of positive and negative emotions were tested but removed due to insignificant improvement of models. As such, the results we reported were from random intercept only models.

We generated interaction terms between communication of emotions and mode of contact to test how mode of contact may moderate the associations between communication of emotions and mood (H3). The sound snippets themselves did not carry information on the mode of social contact (i.e., social contact information was obtained in the EMA every 3 hours). As such, for this set of analysis specifically, we excluded three-hour assessments in which participants had both in-person and phone contact (22% of total eligible assessments) to ensure the recorded conversation happened during a specific mode of contact (in-person or phone). In-person and phone contact were entered as dummy variables (yes/no) indicating whether participants had each mode or not in prior 3 hours. Because emotional expression and mode of contact are both time-varying variables that were measured on the 3-hour assessment level (level 1), the models considered the within- and between-person components for both variables. The models included the assessment-level interaction terms between emotional expression and social contact, as well as the cross-level interaction between assessment-level emotional expression and participant-level social contact. The outcomes were positive and negative mood in two separate models. Random slopes of mode of social contact (in-person and phone) were included in the model. Equations for models corresponding to all three hypotheses are included in supplementary materials. The data met the assumption of multilevel models, including appropriate random effect variances/covariances and sufficient cluster structure. We assumed that the data met residual normality, homoscedasticity, and cross-level exogeneity but these were not formally tested.

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Results

On average, participants scored 1.74 ($SD = 2.49$) and 0.26 ($SD = 0.64$) on communication of positive and negative emotions respectively. The LIWC-generated scores indicated the levels of communication of emotions, but they did not represent the exact number of positive or negative words that participants used. Larger scores of positive and negative emotions indicate a

Table 1 | Sample Descriptive Information (N = 266)

	Participants		
	<i>M</i>	<i>SD</i>	Range
Age	74.08	6.45	65–90
Self-rated health ^a	3.63	1.00	1–5
Proportions			
Women	.54		
Men	.46		
Married	.59		
Race			
White	.83		
Black or African-American	.15		
Asian	.01		
American Indian or Alaska Native	.01		
Hispanic ethnicity	.08		
Education			
High school or less	.13		
Some college	.28		
College or more	.59		
Experiences every 3 hours (n = 4,627)			
Mood			
Positive mood ^b	3.49	0.81	1–5
Negative mood ^c	1.22	0.37	1–4.6
Verbal communication of emotion ^d			
Positive emotion	1.74	2.49	0–33.33
Negative emotion	0.26	0.64	0–9.18
Number of social contacts ^e			
In-person	2.02	2.20	0–16
Phone	0.55	1.14	0–14
Word count ^f	100.37	133.75	0–1197
Social contact proportions ^g			
In-person only	.53		
Phone only	.09		
Both	.22		
Neither	.15		

^a1(poor), 2(fair), 3(good), 4(very good), and 5(excellent). ^b Average of content, loved, calm, and proud from 1 (not at all) to 5 (a great deal). ^c Average of nervous/worried, irritated, bored, lonely, and sad from 1 (not at all) to 5 (a great deal). ^d Scores generated by LIWC indicating verbal communication of emotion, merged to three-hour assessments from 104,746 audio files. ^e Number of in-person and phone contact in prior 3 hours. ^f Number of word count in prior 3 hours, calculated by LIWC. ^g Proportions of 3-hour assessments in which participants reported in-person and phone social contact respectively.

higher frequency of words associated with specific emotions. Participants' average scores on positive and negative mood every 3 hours were 3.49 ($SD = 0.81$) and 1.22 ($SD = 0.37$) respectively. Out of 4,627 3-hour level assessments, participants reported only in-person or phone contact among 53% and 9% of assessments respectively. They further reported having both modes of contact among 22% and neither among 15% of assessments. Participants had an average of 2.02 ($SD = 2.20$) in-person and 0.55 ($SD = 1.14$) phone contact in a 3-hour interval. Table 1 summarizes the descriptive statistics. Supplementary Tables 1 and 2 show the bivariate associations between key variables.

Participants showed considerable intraindividual variability of verbal communication of positive and negative emotions, as well as positive and negative mood, corresponding to intraclass correlation coefficient (ICC) of 0.16, 0.09, 0.75, and 0.54 respectively. Figure 1 demonstrates the

Fig. 1 | Intraindividual Fluctuations in Verbal Communication of Positive and Negative Emotions Throughout the Study Period. Note. X-axis represents the number of occasions/assessments throughout the study period. Y-axis represents the average score of verbal communication of positive and negative emotions across the sample. $n = 4,627$ assessments.

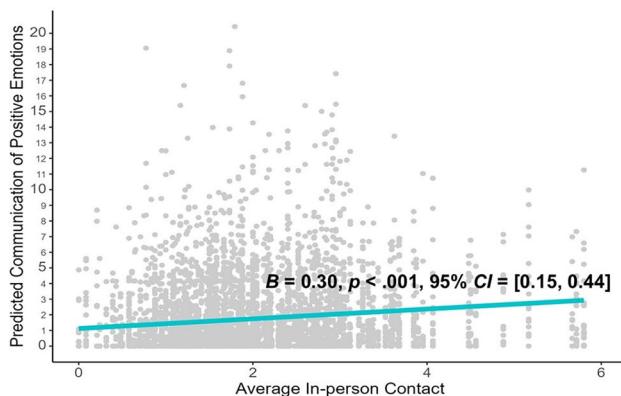
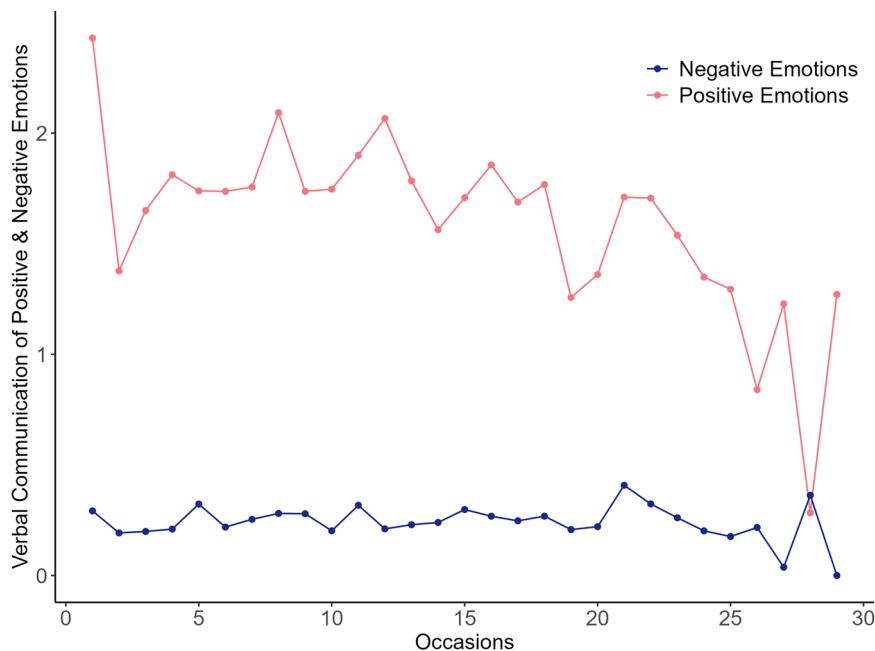
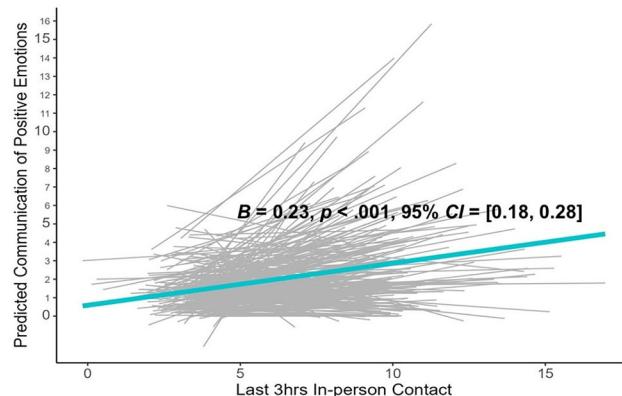


Fig. 2 | In-Person Contact Predicting Positive and Negative Emotional Expression. Note. The left figure shows the association between in-person contact and positive emotional expression on the between-person level. Dots correspond with specific participants. The right figure shows the association between in-person contact and



positive emotional expression on the within-person level, with the gray lines representing observations from specific participants throughout the study period. $n = 4,627$ assessments.

intraindividual variability of the communication of positive and negative emotions across the study period.

Mode of Contact and Communication of Emotion

This study focused on intraindividual associations, and all results of the main effects reported in the text are at the within-person level. That is, comparisons of the same person at different points in time. Between-person associations can be found in the tables. Multilevel models showed that more contact in-person ($B = 0.23, p < .001$, Cohen's $f^2 = 0.040$, 95% CI = [0.18, 0.28]; Fig. 2) and contact by phone ($B = 0.17, p < .001$, Cohen's $f^2 = 0.004$, 95% CI = [0.10, 0.25]) were associated with more verbal communication of positive emotions. However, in-person contact also was significantly associated with more verbal communication of negative emotions ($B = 0.02, p = .001$, Cohen's $f^2 = 0.003$, 95% CI = [0.01, 0.03]) whereas no significant association was found for phone contact (Table 2).

Communication of Emotion, Mode of Contact, and Mood

Higher verbal communication of positive emotions was associated with more positive mood ($B = 0.01, p < .001$, Cohen's $f^2 = 0.005$, 95% CI = [0.01,

0.02]) but did not show a statistically significant association with negative mood. That is, when individuals expressed more positive words than their own average, they reported more positive mood. Expressing negative emotions showed no statistically significant association with either positive or negative mood (Table 3).

The multilevel models involving interaction terms between communication of emotions and mode of contact revealed significant findings. Compared to their personal averages, expressing more positive emotions was associated with more positive mood ($B = 0.04, p < .001$, Cohen's $f^2 = 0.003$, 95% CI = [0.02, 0.06]). Expressing negative emotions was not associated with either positive or negative mood. The interactions on the 3-hour level were not significant, indicating the associations between verbal communication of emotions and mood did not depend on the mode of social contact. The cross-level interaction between assessment-level (*level 1*) communication of positive emotions and participant-level (*level 2*) in-person contact was significant in predicting positive mood ($B = -0.04, p = .011$, Cohen's $f^2 = 0.002$, 95% CI = [-0.06, -0.01]; Table 4). Simple slopes test showed that participants reported more positive mood when they had more positive communications, and such associations were stronger among participant who had less in-person social

Table 2 | Modes of Social Contact Predicting Verbal Communication of Emotion

	Positive Emotions ^a				Negative Emotions ^a			
	B	p	f	95% CI	B	p	f	95% CI
Fixed effects								
Intercept	-0.41	.591	–	[-1.89, 1.07]	0.38	.019	–	[0.06, 0.70]
Social contact ^b								
In person (wp)	0.23	<.001	0.040	[0.18, 0.28]	0.02	.001	0.003	[0.01, 0.03]
Phone (wp)	0.17	<.001	0.004	[0.10, 0.25]	0.01	.173	0.001	[-0.00, 0.04]
In person (bp)	0.30	<.001	0.001	[0.15, 0.44]	0.04	.012	0.000	[0.01, 0.07]
Phone (bp)	0.09	.337	0.000	[-0.09, 0.26]	0.03	.125	0.000	[-0.01, 0.07]
Covariates								
Morning (ref.)	–	–	–	–	–	–	–	–
Afternoon (wp)	0.59	<.001	0.009	[0.41, 0.76]	0.10	<.001	0.003	[0.05, 0.14]
Evening (wp)	0.45	<.001	0.004	[0.26, 0.63]	0.06	.022	0.001	[0.01, 0.11]
Age	-0.01	.180	0.000	[-0.04, 0.01]	-0.01	.012	0.001	[-0.01, -0.00]
Women	0.47	.003	0.001	[0.16, 0.78]	-0.01	.682	0.000	[-0.08, 0.05]
Racial/ethnic minority	-0.08	.646	0.000	[-0.43, 0.27]	0.00	.982	0.000	[-0.08, 0.07]
Married	0.04	.803	0.000	[-0.29, 0.38]	-0.06	.081	0.000	[-0.13, 0.01]
High school or less (ref.)	–	–	–	–	–	–	–	–
College	0.27	.252	0.000	[-0.19, 0.72]	0.01	.840	0.000	[-0.09, 0.11]
College graduate and more	0.43	.062	0.000	[-0.02, 0.88]	-0.04	.420	0.000	[-0.14, 0.06]
Health ^c	0.09	.202	0.000	[-0.05, 0.24]	0.01	.475	0.000	[-0.02, 0.04]
Social network size ^d	-0.01	.346	0.000	[-0.03, 0.01]	-0.00	.393	0.000	[-0.01, 0.00]
Random effects								
Variances (intercept)	0.06	<.001	–	[0.04, 0.09]	0.00	<.001	–	[0.00, 0.00]
Variances (in-person slope)	0.00	.932	–	[0.00, 0.00]	0.00	<.001	–	[0.00, 0.02]
Variances (phone slope)	0.86	.190	–	[0.68, 1.08]	0.03	<.001	–	[0.02, 0.04]
Variances (residual)	4.68	<.001	–	[4.48, 4.88]	0.37	<.001	–	[0.36, 0.39]
-2 log likelihood	20812.83				8837.78			
Number of observations	4631				4631			

wp = within-person. bp = between-person. Between-person level effect of time-varying predictors were considered but omitted from the table. All continuous predictors centered on the grand mean. ^a Words usage indicating verbal communication of positive and negative emotions, generated by LIWC. ^b Number of different modes of social contact in the prior 3 h. ^c 1 (poor) to 5 (excellent). ^d Number of social partners in the social convoy. $n = 4,627$ assessments.

contact ($B = 0.03, p < .001, 95\% \text{ CI} = [0.02, 0.04]$), compared to those who had more social contact on average throughout the study period ($B = 0.01, p = .041, 95\% \text{ CI} = [0.00, 0.02]$; Fig. 3).

Sensitivity Analysis

We compared the verbal communication of emotions between in-person and phone contact by limiting analyses to assessments during which participants reported only in-person or phone contact (i.e., excluding assessments with both in-person and phone contact, and neither). A dummy variable for in-person contact was generated and phone contact was entered as the reference group. Compared to phone contact, participants had more verbal communication of positive emotions during in-person contact ($B = 0.41, p = .016, \text{Cohen's } f^2 = 0.002, 95\% \text{ CI} = [0.08, 0.75]$), but no significant difference was found for negative emotions.

The content of conversations may be influenced by the relationship with the involved social partner. Older adults who are married share more time in person and may be more likely to share emotions with spouses⁴⁵. We re-estimated models of the associations between mode of contact and communication of emotions excluding the assessments during which participants encountered their spouse. Results showed the same pattern, such that participants expressed more positive emotions during both in-person and phone contact, yet only in-person contact was statistically significantly associated with expressing more negative emotions, even after excluding contact with romantic partners.

We also reported the results without controlling the assessment-level and participant-level covariates to avoid overcontrolling issues⁴⁶. The results remained consistent with the models that controlled the covariates. Specifically, both in-person ($B = 0.24, p < .001, \text{Cohen's } f^2 = 0.043, 95\% \text{ CI} = [0.19, 0.29]$) and phone ($B = 0.19, p < .001, \text{Cohen's } f^2 = 0.005, 95\% \text{ CI} = [0.12, 0.27]$; Supplementary Table 3) contact were associated with more verbal communication of positive emotions, but only in-person contact was associated with more verbal communication of negative emotions ($B = 0.02, p < .001, \text{Cohen's } f^2 = 0.004, 95\% \text{ CI} = [0.01, 0.03]$). Regarding verbal communication and mood, only verbal communication of positive emotions was associated with more positive mood ($B = 0.01, p < .001, \text{Cohen's } f^2 = 0.005, 95\% \text{ CI} = [0.01, 0.02]$; Supplementary Table 4). Verbal communication of neither positive nor negative mood was associated with negative mood. For the models examining interactions between verbal communication of emotions and mode of social contact on mood, verbal communication of positive emotions was associated with more positive mood ($B = 0.04, p < .001, \text{Cohen's } f^2 = 0.003, 95\% \text{ CI} = [0.02, 0.06]$; Supplementary Table 5). The interaction between verbal communication of emotion and mode of social contact on the 3 h assessment level was not significant.

Additionally, given that gender may play a role in verbal communication of emotion²¹, we investigated models with gender as a moderator. Gender did not significantly moderate the association between social contact and mood (Supplementary Table 6). The association between verbal expression of positive emotion and mood varies by gender ($B = 0.01,$

Table 3 | Verbal Communication of Emotion Predicting Positive and Negative Mood

	Positive Mood ^a				Negative Mood ^b			
	B	p	f	95% CI	B	p	f	SE
Fixed effects								
Intercept	4.07	<.001	–	[3.14, 5.00]	0.89	<.001	–	[0.53, 1.26]
Communication of emotion ^c								
Positive (wp)	0.01	<.001	0.005	[0.01, 0.02]	-0.00	.304	0.000	[-0.01, 0.00]
Negative (wp)	0.01	.142	0.000	[-0.00, 0.03]	-0.00	.855	0.000	[-0.01, 0.01]
Positive (bp)	0.05	.220	0.000	[-0.03, 0.13]	-0.02	.266	0.000	[-0.05, 0.01]
Negative (bp)	-0.35	.062	0.000	[-0.72, 0.02]	0.33	<.001	0.000	[0.18, 0.47]
Covariates								
Morning (ref.)	–	–	–	–	–	–	–	–
Afternoon (wp)	0.01	.667	0.000	[-0.02, 0.04]	0.03	.009	0.001	[0.01, 0.05]
Evening (wp)	0.01	.499	0.000	[-0.02, 0.05]	0.01	.177	0.000	[-0.01, 0.04]
Age	-0.00	.456	0.000	[-0.02, 0.01]	-0.00	.666	0.000	[-0.01, 0.00]
Women	-0.01	.911	0.000	[-0.21, 0.19]	-0.01	.800	0.000	[-0.09, 0.07]
Racial/ethnic minority	0.21	.057	0.000	[-0.01, 0.42]	-0.05	.225	0.000	[-0.14, 0.03]
Married	0.11	.285	0.000	[-0.09, 0.30]	0.00	.920	0.000	[-0.07, 0.08]
High school or less (ref.)	–	–	–	–	–	–	–	–
College	0.06	.698	0.000	[-0.23, 0.34]	-0.01	.915	0.000	[-0.12, 0.11]
College graduate and more	-0.16	.271	0.000	[-0.45, 0.13]	0.04	.472	0.000	[-0.07, 0.15]
Health ^d	0.10	.025	0.000	[0.01, 0.19]	-0.07	<.001	0.000	[-0.10, -0.03]
Social network size ^e	0.02	.001	0.000	[0.01, 0.03]	-0.01	.038	0.000	[-0.01, 0.00]
Random effects								
Variances (intercept)	0.40	<.001	–	[0.38, 0.54]	1.35	<.001	–	[0.06, 0.08]
Variances (residual)	0.93	<.001	–	[0.15, 0.16]	1.38	<.001	–	[0.06, 0.07]
-2 log likelihood	5443.86				1130.98			
Number of observations	4532				4533			

wp = within-person. bp = between-person. Between-person level effect of time-varying predictors were considered but omitted from the table. All continuous predictors centered on the grand mean. ^a Average of content, loved, calm, and proud from 1 (*not at all*) to 5 (*a great deal*). ^b Average of nervous/worried, irritated, bored, lonely, and sad from 1 (*not at all*) to 5 (*a great deal*). ^c Words usage indicating verbal communication of positive and negative emotions, generated by LIWC. ^d 1 (*poor*) to 5 (*excellent*). ^e Number of social partners in the social convoy. *n* = 4,627 assessments.

$p = .039$, Cohen's $f^2 = 0.001$, 95% CI = [0.00, 0.02]; Supplementary Table 7), such that for women, verbal expression of positive emotion was associated with more positive mood ($B = 0.02$, $p < .001$, 95% CI = [0.01, 0.02]), yet the association was not significant for men. Three-way interactions involving verbal expression of emotion, mode of social contact, and gender were not significant (Supplementary Table 8).

Models predicting participants mood controlling autoregression (i.e., mood reported in the previous 3 hours) were reported in Supplementary Table 9. Results remained the same after controlling autoregression, such that verbal expression of positive emotion was associated with more positive mood ($B = 0.01$, $p < .001$, Cohen's $f^2 = 0.005$, 95% CI = [0.01, 0.02]). No significant associations were found between verbal expression of negative emotion and either positive or negative mood.

Discussion

Using an ecologically valid method to capture sound and self-reports of social contact throughout the day, the current study considered verbal communication of positive and negative emotions during in-person and phone contact as well as potential benefits of communicating emotions. Older adults communicated positive emotions during both in-person and phone contact. They tended to communicate more negative emotions during in-person contact, yet significant associations between phone contact and verbal communication of emotions were not detected. Older adults experienced higher positive mood when they communicated positive emotions, regardless of the mode of contact. Not all older adults have the same opportunity for in-person contact, and the findings also had

implications for older adults who typically have less in-person contact. Participants who had less in-person contact on average experienced a greater increase in positive mood when they communicated positive emotions, compared to those who had more in-person contact on average.

Communication of Emotion and Well-being in Late Life

Findings revealed that verbal communication of positive emotions was associated with better mood; however, communication of negative emotions was not statistically significantly associated with better or worse mood. These findings align with the Interpersonal Model of Capitalization which posits that by sharing positive feelings, individuals enhance their positive emotions and derive emotional benefits that extend beyond the original positive events²³. The amplifying effect of sharing positive emotions has been found in previous studies mainly among younger and middle-aged populations^{23,45}. This study contributes to the current body of literature by examining older adults' interpersonal approaches in emotion regulation, highlighting the advantages of sharing positive feelings in their day-to-day experiences.

Interestingly, no evidence of significant associations was found between communicating negative emotions and either positive or negative mood. Prior studies yield mixed findings and suggest that the emotional outcomes of communicating negative emotions may be complex^{46,47}; implications of sharing negative emotions depend on the timing of disclosure, characteristics of the negative experience itself, surrounding social context, and social partners' responses⁴⁸. For example, communicating negative emotions to a social partner was found to be helpful for recent

Table 4 | Verbal Communication of Emotion Predicting Positive and Negative Mood, Moderated by Mode of Contact

	Positive Mood ^a				Negative Mood ^b			
	B	p	<i>f</i>	95% CI	B	p	<i>f</i>	95% CI
Fixed effects								
Intercept	4.12	<.001	–	[3.14, 5.10]	0.95	<.001	–	[0.57, 1.34]
Communication of emotion ^c								
Positive (wp)	0.04	<.001	0.003	[0.02, 0.06]	-0.01	.183	0.000	[-0.02, 0.00]
Negative (wp)	0.01	.837	0.000	[-0.06, 0.08]	0.02	.450	0.000	[-0.03, 0.06]
Positive (bp)	0.04	.308	0.000	[-0.04, 0.12]	-0.01	.380	0.000	[-0.04, 0.02]
Negative (bp)	-0.35	.062	0.000	[-0.72, 0.02]	0.33	<.001	0.000	[0.18, 0.47]
Mode of contact ^d								
In-Person (wp)	0.04	.006	0.002	[0.01, 0.07]	-0.02	.212	0.001	[-0.04, 0.01]
Phone (wp)	-0.05	.037	0.001	[-0.10, -0.00]	0.03	.130	0.002	[-0.01, 0.07]
In-Person (bp)	0.10	.672	0.000	[-0.35, 0.54]	-0.13	.161	0.000	[-0.30, 0.05]
Phone (bp)	-0.59	.167	0.000	[-1.42, 0.25]	0.06	.739	0.000	[-0.27, 0.38]
Communication of emotion × Mode of contact								
Positive (wp) × In-person (wp)	-0.01	.415	0.000	[-0.02, 0.01]	0.00	.618	0.000	[-0.01, 0.01]
Positive (wp) × Phone (wp)	-0.01	.651	0.000	[-0.03, 0.02]	-0.00	.873	0.000	[-0.02, 0.01]
Negative (wp) × In-person (wp)	0.00	.894	0.000	[-0.05, 0.05]	0.01	.610	0.000	[-0.02, 0.04]
Negative (wp) × Phone (wp)	-0.00	.967	0.000	[-0.09, 0.09]	-0.02	.477	0.000	[-0.08, 0.04]
Positive (wp) × In-person (bp)	-0.04	.011	0.002	[-0.06, -0.01]	0.01	.147	0.001	[-0.00, 0.03]
Positive (wp) × Phone (bp)	-0.04	.285	0.000	[-0.11, 0.03]	-0.00	.892	0.000	[-0.05, 0.04]
Negative (wp) × In-person (bp)	0.03	.599	0.000	[-0.07, 0.13]	-0.01	.728	0.000	[-0.08, 0.05]
Negative (wp) × Phone (bp)	-0.12	.353	0.000	[-0.36, 0.13]	-0.14	.082	0.001	[-0.30, 0.02]
Covariates								
Morning (ref.)	–	–	–	–	–	–	–	–
Afternoon (wp)	0.01	.620	0.000	[-0.02, 0.04]	0.03	.010	0.001	[0.01, 0.05]
Evening (wp)	0.01	.463	0.000	[-0.02, 0.05]	0.01	.239	0.000	[-0.01, 0.03]
Age	-0.00	.550	0.000	[-0.02, 0.01]	-0.00	.576	0.000	[-0.01, 0.00]
Women	-0.01	.952	0.000	[-0.21, 0.20]	-0.01	.700	0.000	[-0.09, 0.06]
Racial/ethnic minority	0.21	.061	0.000	[-0.01, 0.42]	-0.06	.164	0.000	[-0.15, 0.02]
Married	-0.01	.954	0.000	[-0.25, 0.23]	0.05	.271	0.000	[-0.04, 0.15]
High school or less (ref.)	–	–	–	–	–	–	–	–
College	0.06	.661	0.000	[-0.22, 0.35]	-0.01	.854	0.000	[-0.12, 0.10]
College graduate and more	-0.14	.339	0.000	[-0.44, 0.15]	0.03	.579	0.000	[-0.08, 0.14]
Health ^e	0.10	.033	0.000	[0.01, 0.19]	-0.06	<.001	0.000	[-0.10, -0.03]
Social network size ^f	0.02	<.001	0.000	[0.01, 0.03]	-0.01	.029	0.000	[-0.01, -0.00]
Random effects								
Variances (intercept)	0.44	<.001	–	[0.37, 0.53]	0.07	<.001	–	[0.06, 0.08]
Variances (in person)	0.01	<.001	–	[0.00, 0.03]	0.01	<.001	–	[0.01, 0.02]
Variances (phone)	0.00	.973	–	[0.00, 0.00]	0.02	<.001	–	[0.01, 0.03]
Variances (residual)	0.15	<.001	–	[0.15, 0.16]	0.06	<.001	–	[0.06, 0.06]
-2 log likelihood	5410.19				1063.34			
Number of observations	4532				4533			

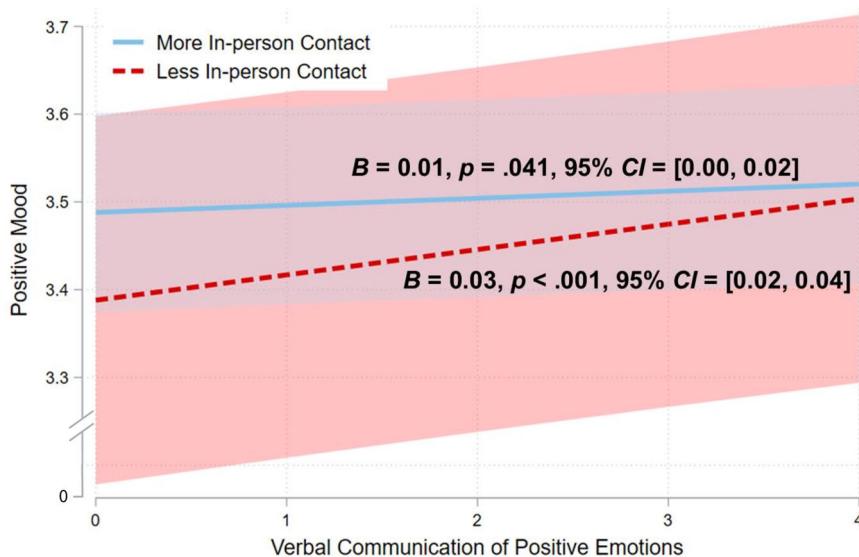
wp = within-person. bp = between-person. Between-person level effect of time-varying predictors were considered but omitted from the table. All continuous predictors centered on the grand mean. ^a Average of content, loved, calm, and proud from 1 (*not at all*) to 5 (*a great deal*). ^b Average of nervous/worried, irritated, bored, lonely, and sad from 1 (*not at all*) to 5 (*a great deal*). ^c Words usage indicating verbal communication of positive and negative emotions, generated by LIWC. ^d Assessments that involved either in-person or phone contact. ^e 1 (*poor*) to 5 (*excellent*). ^f Number of social partners in the social convoy. *n* = 4,627 assessments.

negative events, but not for more distant negative events. Talking about distant negative events may reactivate depressive feelings and lead to ruminations⁴⁶. In sum, the association between communicating negative feelings and emotional well-being may be complicated, warranting further studies to examine the link under specific conditions.

Mode of Contact and Communication of Emotion

As hypothesized, older adults communicated more negative mood during in-person contact compared to phone contact; yet contrary to the hypothesis, they communicated similar levels of positive mood during in-person and phone contact. Compared to sharing positive emotions,

Fig. 3 | The Interaction Between Verbal Communication of Positive Emotion and the Average Level of In-person Contact, Predicting Positive Mood.
Note. Lines represent predicted values from multi-level models for participants with more in-person contact (blue solid line) and less in-person contact (red dashed line). Shaded areas represent 95% confidence intervals around the predicted values.
n = 4,627 assessments.



disclosing negative emotions requires higher levels of mutual understanding and stronger interindividual bonds¹. Older adults may perceive in-person as a better modality for sharing negative feelings that encompasses multiple forms of information and provides opportunities for social support and active response. A study observed aging couples' in-person discussions and found that caring behaviors, mutual understanding, and active response appeared to protect them from emotional stress⁴⁹.

Additionally, a review of the literature suggests that under many conditions, communication of negative emotion can mitigate distress and affect personal relationships in positive ways⁵⁰. Two experimental studies with young adults revealed that in-person social support was linked to better emotional outcomes, compared to other modes of contact (e.g., text)⁵¹. A study of college students further revealed that willingness to disclose negative emotion may be influenced by perceived availability of support⁵². As such, older adults may perceive in-person as a more effective mode to receive support and thus more willing to communicate their negative emotions in person.

In sum, although older adults share positive emotions through both in-person and phone contact, it may be important for individuals to have in-person outlets and receive social support in person when negative events happen¹. Our findings underscore the potentially irreplaceable role of in-person contact in conveying negative feelings, building deeper social ties, and promoting well-being in older adults' daily lives.

Mode of Contact and Benefits of Verbal Communication of Emotion

Regarding the emotional benefits from different modes of social contact, contrary to our prediction that the emotional benefit of communicating positive emotions would be stronger during in-person contact, when examined every 3 hours throughout the day, verbal communication of positive emotions was associated with better mood, but this association did not vary significantly by mode of contact. This finding suggests that the concurrent association between communicating positive emotion and better mood may go beyond the modality of social contact and the availability of information cues. In the process of amplifying positive experiences, verbal communication with social partners may already be sufficient to boost positive mood²³. Additionally, we found that the people who had less in-person contact on average benefited more from verbal communication of positive emotions (i.e., experience a larger boost in positive mood), compared to those who had more in-person contact on average. This was the case, even accounting for marital status. Although people who had less in-person contact reported lower positive mood in general, communicating

positive emotions may strengthen social connections and help them achieve better mood over time²⁴. Findings highlight the importance of in-person contact, and also suggest that when in-person contact is not accessible, communicating positive feelings via other modalities may provide older adults emotional benefits⁵³.

Disclosing negative emotions was not statistically significantly associated with mood regardless of the mode of social contact. Older adults had more verbal communication of negative emotion during in-person contact compared to when they had no contact, yet this association was not observed during phone contact, suggesting older adults may prefer communicating negative emotion during in-person contact rather than phone contact. In-person contact may create venues for better social support and more active reactions, yet in the current study, statistical analyses did not provide evidence that older adults benefit emotionally from talking about negative feelings. Importantly, the current study focuses on the potential emotional benefits of verbally expressing emotions. However, the reversed direction is also plausible, such that older adults may experience improved mood in in-person settings with social partners⁵, which could in turn increase their likelihood of expressing emotions. Although this alternative direction is beyond the scope of the current study, it warrants further analysis to understand the social contact dynamics across different modes of contact.

As previously mentioned, additional factors may contribute to the effectiveness and emotional benefits associated with expressing negative mood (e.g., social expectation, social partners' response strategy, personality)⁴⁶. For example, a series of studies involving college students in different countries found that when participants did not perceive that other people expected them to be sad, they reported greater levels of sadness⁵⁴, highlighting the impact of social expectation on emotional communication to social partners. Future studies may consider these intrapersonal, interpersonal, and contextual factors when examining negative emotional expression via different modes of contact in late life.

Limitations

The current study measured participants' verbal communication of emotions and mood every three hours throughout the day. This study collected a large sample of sound files and provided information about social contact every three hours, propelling an understanding of naturalist language in social contexts. However, this study examined concurrent associations between verbal communication of emotion and mood, which does not indicate a causal relationship. It is possible that verbal communication of emotion (i.e., the use of words) reflects individuals' mood rather than

leading to changes in mood⁵⁵. Moreover, the current study design did not allow us to detect if a specific conversation happened in person or by phone. To isolate the effect of in-person and phone contact, we constrained our data to 3-hour intervals where participants only had in-person or phone contact, by excluding three-hour intervals in which participants indicated they had both in-person and phone contact. Future studies may consider study designs (e.g., event-contingent methods where people provide self-reports when the events actually occur) to examine the emotional communication in each mode of contact as it occurs. We did not find associations between verbal communication of negative emotions and mood. Yet, given that statistical analyses did not detect associations between discussing negative events and worse mood, this may indicate that interpersonal communication helps to alleviate negative mood among older adults. Using an event-contingent design that closely tracks individuals' interpersonal behaviors following specific events may help illuminate such associations.

Importantly, the current study focuses on individuals in late life, a stage where people prioritize emotionally meaningful goals and emphasize emotional meaning in social contact³. In contrast, younger people may differ in their frequency of social contact, choice of social partners (e.g., people at school or work may have more contact with friends and colleagues vs. older adults have more contact with families), and preference of mode of contact (e.g., younger people may be more used to various modes of contact, including digital contact⁵⁶). These age-related differences in social goals and behaviors may contribute to variations in emotional experiences during social contact, underscoring the need for future studies to investigate individuals' communication of emotion across different age groups.

Furthermore, we studied participants' verbal communication of emotions by using linguistic features extracted by LIWC. Future studies may utilize other approaches to examine specific aspects of daily conversations. For example, dyadic data may offer insights into conversation dynamics, support exchange, and social partners' feedback⁵⁷. Turn-level datasets (i.e., separating individuals' speaking to multiple segments) may be appropriate for investigating conversational behaviors⁵⁸, though doing so in a naturalistic context introduces issues of practicality of obtaining consent and ethical considerations of use of data. Additionally, LIWC compared scripts to its internal dictionary. This approach provides important information on participants' use of emotional words, yet may overlook subtle information that is not explicitly conveyed through the word choice (e.g., sarcasm). As such, applying natural language processing algorithms for sentiment analysis may yield information on linguistic features and individuals' emotional states⁵⁹. Furthermore, the current study focused on participants' spoken language. A small qualitative study showed that older adults prefer phone or in-person communication much more than texting or electronic communication⁶⁰. However, given the increase in use of technologically-mediated communication among older adults (e.g., texting, social media)¹⁰, future studies may examine older adults' written communication of emotions and its contribution to well-being. In addition to the mode of contact, future studies could explore other aspects of social contact, for example, the duration of social contact, the relationship with social partners (e.g., spouse, children, friends), and older adults' emotional experiences.

In sum, this study pushes the field forward by examining older adults' verbal communication with social partners in naturalistic contexts in daily life where they occur. By integrating this data with self-reports of social contact and mood we were able to gain insights into communication of emotions in different modes of contact. Analysis on sound snippets revealed that older adults tended to share positive experiences through both in-person and phone contact, however, they were more likely to communicate negative emotions in-person. Sharing positive emotions during in-person and phone contact was associated with better mood, but sharing negative emotions was not statistically significantly associated with either positive or negative mood. To conclude, in-person contact may allow older adults to communicate more complex emotions, and phone contact may be suited for simpler communications, discussing positive events, but not negative ones.

Data availability

Data and information about the study are available at the National Archive of Computerized Data on Aging (<https://www.icpsr.umich.edu/web/NACDA/studies/38570>). Available datasets at NACDA include variables from the baseline interviews, the ecological momentary assessments, and the language codes for the audiofiles obtained from the Electronically Activated Recorder.

Code availability

The code used for analysis is available on Open Science Framework (<https://github.com/jeanneZ3/Mode-of-Soical-Contact>).

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Author contributions

Shiyang Zhang contributed to conceptualization, methodology, formal analysis, data interpretation, writing- original draft, and visualization. Sibo Gao contributed to data interpretation and writing- review & editing. Karen Fingerman contributed to funding acquisition, study design and data collection, supervision, conceptualization, data interpretation, and writing- review & editing.

Competing interests

The authors declare no competing interests.

Additional information

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Correspondence and requests for materials should be addressed to Shiyang Zhang or Karen L. Fingerman.

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