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RESEARCH ARTICLE

Presence at a distance: Video chat supports intergenerational sensitivity and positive infant affect during COVID-19

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Abstract

COVID-19 disrupted infant contact with people beyond the immediate family. Because grandparents faced higher COVID-19 risks due to age, many used video chat instead of interacting with their infant grandchildren in person. We conducted a semi-naturalistic, longitudinal study with 48 families, each of whom submitted a series of video chats and surveys, and most (n = 40) also submitted a video of an in-person interaction. Families were mostly highly-educated, White/Caucasian, and lived between 1 and 2700 miles apart. We used multilevel models to examine grandparents' and parents' sensitivity during video chat across time (centered at February 1, 2021, the approximate date of vaccine availability). Grandparent video chat sensitivity changed as a function of date and parent sensitivity. Parent sensitivity changed as a function of date, grandparent sensitivity, and geographic distance. We then modeled infants' affective valence during video chat and in-person interactions with their grandparents, which was only predicted by grandparent sensitivity, not modality or other factors. This study demonstrates that caregivers were sensitive toward infants during video chat interactions despite fluctuations in family stress and reduced in-person contact during COVID-19 and that grandparent sensitivity predicted positive infant affect during both video chat and in-person interactions.

When COVID-19 disrupted the ability of grandparents and their infant grandchildren to interact in person, many families used video chat to stay connected (Strouse et al., 2021). With support from their parents, young children were already using video chat before the pandemic to build relationships with relatives at a distance (McClure et al., 2015; Tarasuik & Kaufman, 2017). Just before the pandemic began, parents in the United States estimated that video chat accounted for only 1% of children's (birth to age eight) media exposure (Rideout & Robb, 2020), but COVID-19 shutdowns resulted in substantial growth in these video chat-based interactions (G. Brown & Greenfield, 2021). It is well established that responsive, stable relationships support infant development across domains (Bornstein et al., 2008; Shonkoff & Phillips, 2000). However, most research on infant–caregiver interactions has analyzed in-person interactions between mother–infant dyads (Bretherton, 2010; Cabrera et al., 2018). The unique historical event of the COVID-19 pandemic provides a naturalistic context to examine infant–grandparent dyadic interaction across screens.

1 | INFANT DEVELOPMENT IN AN ECOSYSTEM OF RELATIONSHIPS

Infants develop in a context of interconnected family relationships, each of which is influenced by the others, as well as the family's cultural and historical context (Bronfenbrenner, 1979). In Bronfenbrenner's ecological systems theory, parents typically support development as part of their children's *microsystems* (immediate environment). Grandparent involvement with infants is more variable; although some are primary caregivers and others live with their grandchildren, many nonresidential grandparents play a role in an infant's *exosystem* (indirect environment). As technology has advanced, video chat has allowed grandparents who live near or far to become part of a child's *virtual microsystems* (McClure et al., 2015; Strouse et al., 2021). The COVID-19 pandemic has been a sociohistorical period (i.e., *chronosystem*) that has created additional stressors at all levels of the family ecosystem (Hartshorne et al., 2021). The pandemic has influenced many aspects of the environment supporting infant development, including children's in-person relationships and their virtual and in-person relationships with nonresident grandparents (Strouse et al., 2021).

1.1 | Caregiver sensitivity

Sensitive caregivers are attuned and responsive to infant cues, and it is well established that moment-to-moment sensitivity is associated with socioemotional, attentional, executive function, and language outcomes in children (Bornstein et al., 2008). Although some studies have shown that caregiver sensitivity is relatively stable over time (Behrens et al., 2014), acute and chronic stress have been associated with changes in sensitivity (Booth et al., 2018). Changes in caregiver sensitivity during stressful periods are important to understand, as sensitivity is thought to moderate the relationship between ecological stressors and infant emotional development (Senehi et al., 2021).

The pandemic is a uniquely stressful, ongoing period that has directly impacted family relationships, especially prior to vaccine availability when many families socially distanced themselves from elders to protect them. However, a lack of contact with the elder generation could also result in reduced support for parents. Before the pandemic, Neuhauser (2018) found that maternal sensitivity decreased as stress accumulated and that a lack of social support for mothers was also associated with decreased sensitivity toward their children.

Longitudinal studies have already captured increased stress and anxiety in a general sample of more than 300,000 U.S. adults during the COVID-19 pandemic (e.g., Twenge & Joiner, 2020), and one state-based study of several thousand adults found that parenting a child under the age of 18 was one of several significant demographic predictors of reduced mental health during the pandemic (Danzi et al., 2022). Early in the pandemic (April 2020) the Rapid Assessment of Pandemic Impact on Development-Early Childhood (RAPID-EC) began to survey a nationally-representative sample of approximately 1000 parents of children under the age of 5 years. The survey, which was initially administered every week and later every 2 weeks, assessed self-reported factors including detailed questions about child health and wellness, parent physical and mental health, economic stressors, and child care. Researchers also examined parents' current experiences of stress including measures of overall stress, loneliness, anxiety, and stress directly associated with parenting (RAPID-EC Research Group, 2020a). The RAPID-EC survey captured trends and fluctuations in parent stress, which increased and decreased as the context evolved (RAPID-EC Research Group, 2020b, 2021). RAPID-EC researchers found that stress levels were associated with levels of social support and material hardship (RAPID-EC Research Group, 2020b). Other factors including job loss, family sickness, local policies, and disease outbreaks may have influenced parents' stress levels at different points during the pandemic. Grandparents' experiences of stress have not been measured throughout the pandemic in the same way, but ongoing stressors could also have been associated with sensitivity toward their infant grandchildren. We therefore tested "current stressors", a composite of questions for both parents and grandparents used by RAPID-EC researchers, as a predictor in our parent and grandparent sensitivity models.

1.2 | Socially contingent interaction during video chat

Caregiver sensitivity relies on real-time responsiveness to infants' cues, and infants are emotionally sensitive to even subtle changes in *social contingency* (Nadel et al., 1999), a key ingredient in adult–infant interactions that supports socioemotional development, attachment, and language (Beebe et al., 2010; Goldstein & Schwade, 2008; Tamis-LeMonda et al., 2014). Unlike phone calls, video chat provides visual as well as auditory social contingency, allowing for real-time social interactions (Ballagas et al., 2009; McClure et al., 2015, 2018; Myers et al., 2017; Roseberry et al., 2014; Strouse et al., 2018; Tarasuik et al., 2013; Troseth et al., 2018). Therefore, the American Academy of Pediatrics (2016) notes that video chat is an exception to recommendations about screen time limits for young children.

1.3 | Studies of child engagement and affect during video chat

Video chat allows infants to engage in real-time interactions with distant partners, and prior studies have demonstrated that infants show similar patterns of engagement with familiar adults during video chat interactions as they do during in-person interactions (McClure & Barr, 2017; McClure et al., 2018; Myers et al., 2017; Roseberry et al., 2014). Several research groups have directly compared video chat and in-person interactions with known adults. In one study of distress during parental separation, children aged 17 months to 5 years remained content if the parent was virtually available. In this study, children exhibited similar interactivity levels with parents in person and virtually (Tarasuik et al., 2011), suggesting that video chatting with caregivers can provide a sense of security for young children. Other studies have assessed infant positive–negative affective valence and physiological responses during in-person and video chat interactions with caregivers. McClure et al. (2020) compared infant–mother engagement in three modalities: face-to-face, prerecorded video, and video chat. The 6- to 12-month-olds who played peek-a-boo with their mothers via video chat smiled as frequently as babies who played with their mothers face-to-face, and there were no differences in physiological measures of emotional reactivity between modalities. The best predictor of positive infant affective responses in all cases was the parents' global sensitivity score. This finding in the medium of video chat echoes the results of in-person studies examining the relationship between parental sensitivity and infant affective responsiveness (Braungart-Rieker et al., 2001). These studies found few measurable affective differences between live and video chat interactions with known individuals during infancy, but all were conducted before the COVID-19 pandemic, when video chat interactions were more likely to be supplemented by frequent live interactions. Presumably, if difficulty learning from screens (Barr, 2013; Troseth, 2010) applies to encoding information about people, then cumulative live interactions build stronger representations than video chat interactions. Physical contact and joint attention, which are known to build attachment relationships, may have been absent or rare between grandparents and infants during the pandemic, providing less of an existing relationship for video chat to sustain and instead requiring more relationship building via video chat. In addition, prior studies examined infants as well as toddlers but have not focused on infants born during a pandemic who had limited opportunity to build strong in-person relationships prior to social distancing and travel restrictions.

1.4 | Parent scaffolding and studies of joint visual attention during video chat

Infants who engage in video chat use devices designed for adults (McClure et al., 2018; Strouse et al., 2021), so in-person adult scaffolding is needed to support engagement with remote social partners (Myers et al., 2018; Strouse et al., 2018). When parents co-view prerecorded videos with infants (6–18 mo), parent engagement with the screen has been associated with higher levels of infant engagement (Barr et al., 2008; Fidler et al., 2010). McClure et al. (2018) also found that a remote grandparent's sensitivity during video chat was associated with higher levels of joint visual attention between grandparents and 6- to 24-month-old children as well as higher levels of child looking time during the chat. Taken together, existing studies suggest that sensitivity from the on-screen partner and the in-person co-viewer together support infant engagement during video chat interactions.

2 | THE ROLE OF GRANDPARENTS IN THE FAMILY ECOSYSTEM

Grandparent involvement is generally related to positive developmental outcomes in grandchildren (Barnett et al., 2010; Duflos et al., 2020; Ruiz & Silverstein, 2007). Typically, the quality of the grandparent–grandchild relationship has been measured through self-reported closeness (Duflos et al., 2020) rather than behavioral observations. Multiple factors contribute to grandparent–grandchild closeness, including frequency of contact, geographic distance, socioeconomic factors, grandparent age and/or illness, and grandparent–parent closeness (Dunifon & Bajracharya, 2012).

When families live closer together, frequency of contact and reported emotional closeness tend to be higher (Cohn & Morin, 2008; Drew & Smith, 1999; Dunifon & Bajracharya, 2012; Uhlenberg & Hammill, 1998). However, Davey et al. (2009) found that *greater* distance was related to greater emotional closeness after controlling for frequency of contact. During the pandemic, distance may not have been as predictive of how often families met face to face as it was prior to the pandemic, as factors such as local policies and disease outbreaks, the presence or absence of family members with preexisting conditions, and individual comfort with risk may have substantially influenced decisions to meet. Early in the pandemic, during the summer of 2020, frequency of video chat rather than geographic distance predicted grandparent reports of closeness to their young grandchildren (Strouse et al., 2021). In research examining trends from childhood through adolescence, nonresident grandparent–grandchild closeness tends to decrease over time (Dunifon & Bajracharya, 2012), but little is known about this trajectory in infancy, a developmental period when relationships may be disproportionately effective at buffering stress and adverse experiences (Hambrick et al., 2019). Based on the current evidence, geographic distance continues to be an important predictor to consider.

3 | THE PRESENT STUDY

Many questions remain about how infants will be impacted by the COVID-19 pandemic. In this study, we were interested in infants' experiences during video chats, as caregiver sensitivity is likely to have a positive impact on infants' emotional engagement.

In this semi-naturalistic study of 48 families who engaged in infant–grandparent video chat during the COVID-19 pandemic, we focus on predictors of changes in parent and grandparent sensitivity toward the infant over a series of video chats as well as the relationship of grandparent and parent sensitivity to positive infant affect across both video chat and in-person modalities. We preregistered the study design (https://osf.io/kvd97/?view_only=bea26c4c1bc2436da0314f9d98994950) as well as our research questions and survey items at OSF (https://osf.io/kvd97/?view_only=bea26c4c1bc2436da0314f9d98994950). The coding scheme, coding template, data files, and analysis scripts can be found at (https://osf.io/hvk3d/?view_only=ab8699f928aa45a899e93232f8eb6657).

3.1 | RQ 1a and 1b. Predictors of grandparent and parent sensitivity during video chat

First, we sought to understand how both grandparent (1a) and parent (1b) sensitivity toward the infant changed over a series of video chats, considering variables of interest including timing of vaccine release for older adults, individual fluctuations in a combined "current stressors" index for the target adult in the model, the sensitivity of the other adult, the geographic distance between grandparent and infant, and family video chat experience. We predicted that the wide release of a vaccine in February of 2021 for older adults could influence sensitivity as in-person interactions became safer for grandparents, which motivated the use of this date as a center point in our models.

3.2 | RQ 2. predictors of positive infant affective valence during video chat and in-person interactions

Based on the Bronfenbrenner model (Bronfenbrenner, 1979), we predicted that infant affective valence would not be directly impacted by COVID-19 contextual fluctuations but rather by interactions with adults in their microsystems (both in-person and virtual). We predicted that positive infant affective valence would be associated with greater parent and grandparent sensitivity, as well as with age and video chat experience with their grandparents. Based on pre-pandemic research with infants and toddlers (e.g., McClure et al., 2020), we would not have predicted significant differences in infant affective responses to caregivers between video chat and in-person interactions. However, due to likely differences in the ratio of infants' in-person and virtual engagement with their grandparents during the pandemic, as well as the younger age of our sample of children (many of whom were born during the pandemic), we proposed an alternate hypothesis that the modality of interaction (video chat or in-person) would predict infant affective responses. We therefore included modality as a variable that may predict infant valence during interactions in the unique context of the pandemic.

4 | METHOD

4.1 | Participants

4.1.1 | Recruitment

Grandparent–parent–infant triads with an infant born from December 2019 and throughout 2020 were recruited for this study. Triads were recruited from individual parents and grandparents who completed a survey in the summer of 2020 (Strouse et al., 2021) and indicated an interest in participating in a follow-up phase. Additional families were recruited through ResearchMatch, Children Helping Science, preexisting lab and institutional listservs, online forums for families, local retirement and senior centers, and general and targeted Facebook ads. Participants were compensated for their time and received a \$5 e-gift card for each survey completed and a \$10 e-gift card for each video recording. Advertisements were posted in English and Spanish. We aimed to recruit at least 50 triads. Recruitment began in August 2020 and continued until December 2020, by which time 50 triads were successfully recruited. To be eligible for the study, all members of the triad needed to live in the United States or Canada and have access to an electronic device (tablet, computer, phone, etc.) connected to stable WiFi. We excluded two families from the final sample who only submitted one recording each.

The present study was conducted according to the guidelines laid down in the Declaration of Helsinki, with written informed consent obtained from a parent or guardian of each child prior to any assessment or data collection. All procedures involving human subjects were approved by the Institutional Review Board of Georgetown University.

4.1.2 | Final sample

The final sample consisted of 48 triads: infants (18 girls and 30 boys), grandparents (48, all grandmothers), and parents (43 mothers and 5 fathers). At the time of the first video chat session, infant average age was 9.70 months ($SD = 2.57$), grandparent average age was 62.44 years ($SD = 7.2$ years), and parent average age was 33.15 years ($SD = 4.7$ years).

The sample was largely homogeneous, self-reporting as mostly White/Caucasian, and highly educated. Education was measured on a 7-point scale, but the first three low-incidence categories (lower than high school/high school/GED) were collapsed into one category. Detailed information about education, race, and ethnicity is included in Table 1.

The average geographic distance between family members was 605.06 miles ($SD = 725.2$ but the data were skewed, median = 302.7 miles). Distance was estimated by calculating the miles between the latitude and longitude coordinates associated with each party's zip code and/or place name. Due to a large range (~2000 miles) and skew, we log-transformed this variable (as used by Davey et al., 2009), and the natural log is used in our models.

For the 48 triads in our sample, a total of 179 video recordings were collected between October 2020 and October 2021. Most ($n = 37$) provided four videos (three video chats and one in person). Several families ($n = 6$) submitted three video chats and no in-person video, or two video chats and one in-person video ($n = 3$). One family submitted two video chats and no in-person video, and another submitted one video chat and one in-person video. While collection for most families finished in the summer of 2021, some in-person visits took place later that fall due to family schedules. Because we did not give instructions to limit who participated in the video chats, the number of adult and child video chat participants varied across families. We coded all visible participants, but only one target grandparent, parent, and infant were included in this analysis (determined by the family members who completed the initial survey).

4.2 | Design

This was a longitudinal study during which we collected three video chat recordings and one in-person video recording from 48 triads. We measured grandparent and parent sensitivity toward the infant as well as infant valence. The general design is shown in Table 2.

TABLE 1 Demographic characteristics of participants (N's = 48)

Variable		Grandparents		Parents	
		N	%	*n*	%
Education					
	No high school/high school/GED	4	8.33	1	2.08
	2-year degree/trade school	10	20.83	3	6.25
	4-year degree	13	27.08	18	37.5
	Master's degree	12	25	14	29.17
	Ph.D., M.D., law degree	9	18.75	12	25
Self-reported ethnicity					
	Hispanic/Latino(a) - No	44	91.67	43	89.58
	Hispanic/Latino(a) - Yes	2	4.17	5	10.42
	NA	2	4.17	–	–
Self-reported race					
	Black/African/African American	1	2.08	–	–
	White/Caucasian	47	97.92	47	97.92
	Multiracial	–	–	1	2.08

TABLE 2 Overall design of the study

	Enrollment	Video Chats			First In-Person Meeting
		Time point 1	Time point 2	Time point 3	
Timing	Between June and December 2020	At least 1 month after enrollment (beginning Oct 2020)	~ 2 months after time point 1	~ 2 months after time point 2	May have occurred at any time during the study period
Surveys	Enrollment survey (grandparent and parent)	Follow-up survey (grandparent and parent)	Follow-up survey (grandparent and parent)	Follow-up survey (grandparent and parent	No survey
Variables measured from recordings	No recording	Parent sensitivity Grandparent sensitivity Infant valence	Parent sensitivity Grandparent sensitivity Infant valence	Parent sensitivity Grandparent sensitivity Infant valence	Parent sensitivity Grandparent sensitivity Infant valence

4.3 | Instrumentation

Surveys were collected from both parents and grandparents at the beginning of the study and prior to each video chat. All parents and grandparents completed a 90-item enrollment survey in Qualtrics and we report demographics and geographic distance from this survey. Prior to each video chat, the parent and grandparent each completed a 160-item follow-up survey on REDcap. From these surveys, we report items related to the frequency of in-person and video chat contact between the infant and grandparent. Parents and grandparents reported their overall stress, anxiety, and loneliness, as well as specific stress related to parenting and grandparenting using questions from the RAPID-EC 2020 survey bank (RAPID-EC Research Group, 2020a), an ongoing survey conducted by researchers from the University of Oregon to measure the needs, well-being, and health of children and families during COVID-19.

4.3.1 | Demographic variables

Demographic questions covered parent and grandparent education, the geographic location of both parties, and household composition. Participants also reported the birth month of the infant and their own age in years.

4.3.2 | Frequency of contact

Parents and grandparents were asked to self-report how often the grandparent had interacted with the infant, both in person and over video chat, ranging from Every day (4), A few times a week (3), A few times a month (2), Less than once a month (1), and Never (0).

4.3.3 | Overall stress

General stress levels were recorded with a single-item question (Elo et al., 2003) into the following numeric values in terms of frequency of experiencing stress: Not at all = 1, A little bit = 2, Somewhat = 3, A good amount = 4, and Very much = 5.

4.3.4 | Anxiety levels

The Generalized Anxiety Disorder 2-item scale (GAD-2, Kroenke et al., 2007) was included to assess the frequency of participants' anxious feelings and worry. Participants were asked to respond on a scale from “not at all” (0) to “nearly every day” (3), resulting in a total possible score of 6, with a score of 3 out of 6 points indicating anxiety. The scores were re-coded into the following numeric values: Not at all = 0, Several days = 1, More days than half of the days = 2, and Nearly every day = 3, and added together to calculate the GAD-2 score.

4.3.5 | Loneliness

One question about loneliness ("In the past week, how often have you felt lonely?") derived from the NIH toolbox loneliness measure (NIH, 2016) was recorded into the following numeric values: 0 = Never, 1 = Rarely, 2 = Sometimes, 3 = Usually, and 4 = Always.

4.3.6 | Parenting and grandparenting stress

Using questions that were adapted by RAPID-EC (Research Group, 2020a) from the parenting stress index (PSI-SF, Abidin, 2012), we asked parents and grandparents about perceived stress specifically associated with being a parent or a grandparent, respectively. Two questions probing the manageability of parenting/grandparenting and the quality of resources and support were coded into the following values: Strongly agree = 1, Agree = 2, Not sure = 3, Disagree = 4, and Strongly disagree = 5. One question asking about the inability to handle their workload was reverse-coded into the following values: Strongly disagree = 1, Disagree = 2, Not sure = 3, Agree = 4, and Strongly agree = 5. The final question about the support received when one felt overwhelmed or stressed was reverse-coded into the following values: No, I did not feel supported = 5, I felt somewhat unsupported = 4, I felt neither supported nor unsupported = 3, I felt somewhat supported = 2, and I felt very supported = 1.

4.4 | Procedure

Consent and survey data were collected using Qualtrics and REDCap, and video chats were recorded via Zoom. At least one month after the baseline survey ($M = 1.98$ months, $SD = 0.90$ months), parents and grandparents completed a brief (~15 min) REDCap survey prior to their first video chat. Subsequent surveys were sent at 2-month intervals for a total of three REDCap surveys with associated video chat recordings. Families were also asked to submit a recording of their first in-person parent–grandparent–grandchild meeting that occurred during the study period. Consent for surveys and video data was obtained at each wave.

Prior to their first video chat, participants met with experimenters via Zoom to prepare. During this meeting, researchers provided general instructions on Zoom usage, informing participants that the call did not have a time restriction but should last at least 15 min and that when possible, all three participants should be on camera. Prior to scheduled family Zoom sessions, a link was provided and parents, grandparents, and infants met without the experimenter. The video was automatically recorded and uploaded to the Zoom cloud.

Parents also received a 10-min phone call prior to their in-person meeting to ensure that they were prepared to use Zoom to record an in-person interaction of at least 5 min. After the call, participants received an email with the Zoom link for their preferred date and time (e.g., Saturday morning) and written instructions. 40 families submitted a codeable video of an in-person interaction between the target infant and grandparent. Recordings from the video chats and live meetings were shared with participants to confirm that they wanted the data to be used by the research team and then de-identified and coded by trained research assistants (RAs) for behaviors of interest related to sensitivity and affect.

4.5 | Calculated and coded variables

4.5.1 | Variables calculated from parent and grandparent-submitted surveys

Family-level frequency of contact variables

At each time point, parent/grandparent responses to frequency items (every day [4] to never [0]) were averaged to create family-level video chat frequency and in-person frequency scores. Then family-level frequency at each time point was multiplied by the child's age to estimate a cumulative amount of each type of contact at each time point. That is, a 12-month-old child who had been chatting once per week had more cumulative video chat experience than a 6-month-old child who had been chatting once per week. Multiplying frequency by age therefore resulted in new variables to estimate the total amount of infants' *video chat experience* and *in-person contact*.

Order of submission and modality of recordings

Families could submit an in-person video at any time during the study, resulting in variability between families in terms of the order of video chat and in-person videos. To account for this, we included the number of video chats submitted prior to the in-person video, ranging from 0 to 3, in the infant valence model. We also created a binary variable to represent the modality of each video, either in-person or video chat.

Current stressors index variable

Following the approach taken by the RAPID-EC Research Group (November 2021), we created a composite measure of current stressors by combining the scores of overall stress, anxiety, loneliness, and parenting/grandparenting specific stressors. A Cronbach's alpha of 0.76 indicated the combined variable was internally consistent.

4.5.2 | Observational behavioral video coding protocol

Screening of videos for inclusion

The length of video files submitted by families varied, and the videos sometimes included periods with no one on camera or extended grandparent/parent interactions while the infant was off-screen. To standardize videos for our analysis, if a video chat was longer than 25 min, trained RAs selected 25 min in which grandparents/infants were interacting on screen. Average video chat length after truncation was 18.00 min ($SD = 5.57$ min). In-person videos were all shorter than 25 min and so were not truncated ($M = 9.00$ min, $SD = 5.46$ min). To compare sensitivity and affect variables across videos of different lengths, a single mean value for each variable was calculated at each time point for each participant.

Coding protocol

Zoom recordings were uploaded to Box for secure storage, and Datavyu spreadsheets were created for coding. Datavyu is an open-source software that allows coders to attach codes to timestamps (Datavyu Team, 2014). Sensitivity and infant valence were coded in 30s blocks, and coders were instructed to code NA for any 30s block in which the target participant was not visible and/or audible for more than a third of the 30s block. Coders were trained to criterion (Kappa value of 0.70) and 17.4% of videos were double-coded, achieving Kappas of 0.86 for grandmother sensitivity, 0.91 for mother sensitivity, 0.90 for father sensitivity, and 0.76 for infant valence.

Sensitivity (grandparent and parent)

Every 30 seconds, coders rated all visible adults on their sensitivity using a 9-point subscale of the Emotional Availability Scales (Biringen et al., 2000), which combines warmth, sensitivity, and responsiveness to infant cues. Figure 1 provides illustrations of the various ways grandparents engaged with infants. In this measure, a score of nine epitomizes the "dyadic dance," in which the caregiver is highly attuned to infant cues, responding warmly and sensitively during the majority of the coded period. A seven or eight reflects a high level of sensitivity, but with more interruption or less consistency. A score of five reflects less consistency, a score of three is somewhat insensitive, and a score of one is highly insensitive. Although the subscales can be used to assess sensitivity to any relational partner, we only coded each adult participant for sensitivity toward the target infant (even when other children or adults were present). We then calculated a mean sensitivity score for both the parent and grandparent at each time point by averaging across all 30s blocks.

Infant affective valence

Although questions remain about core mechanisms and measures of infant emotional development (see Buss et al., 2019), infant affect can be evaluated on core dimensions of valence (negative to positive) and arousal (low to high, Posner et al., 2005). In our study, trained coders rated infant valence (1–7, negative to positive) in 30s blocks based on the infant's predominant affective valence during the majority (approximately two thirds) of the 30s block. If an infant's affect was highly variable over the course of 30s, the coder was instructed to choose the most frequent level of valence. For example, to receive a rating of a seven during a 30s period, the infant would need to sustain a highly positive valence (characterized by smiling, laughing, or engaging warmly) for at least 20s. See Figure 1, upper right, for an example of an infant displaying positive affect, and top left for a more neutral affect. We calculated mean valence per session by averaging infant valence across all coded 30s blocks.

4.5.3 | Model building

To address our research questions, we used hierarchical linear modeling to fit growth models using the *lmer* function in R and maximum likelihood estimation. Growth models to address research questions 1 and 2 were centered at February 1, 2021. This date, which was near the middle of data collection, represented a time after the winter 2020–21 peak of COVID-19 infections in the United States, when

FIGURE 1 Illustrations from the triads' interactions. Video chat and in-person interactions were coded for adult sensitivity and infant affective valence. Note that the bottom left image was collected on a cell phone device. Photos were provided with permission by parents and grandparents

the vaccine was becoming available to many older Americans. Centering at this time point had the added benefit of providing estimates of growth near the middle of data collection, rather than at either end, and avoiding the potential problem of multicollinearity between the linear and quadratic growth terms during the model-fitting process. All other predictors in these models were left uncentered. Growth models to address research question 3 were grand-mean centered on the infant's age (M = 12.15 months, SD = 3.5). Grandparent and parent sensitivity were also grand-mean centered; other predictors were left uncentered.

5 | RESULTS

5.1 | Descriptive statistics

Family video chat experience and in-person contact at each time point are included in Table 3 as a function of infant age, showing that during this period grandparents saw their grandchildren more via video chat than in person. Perhaps not surprisingly, parents reported overall higher levels of current stressors than grandparents, but both groups reported relatively low stress (max possible current stressors score = 36). Both grandparents' and parents' mean sensitivity scores were relatively high at each time point, between 6.78 and 7.67 (out of 9). Infant valence was mostly positive, with mean valence scores at each time point ranging from 4.5 to 4.61 (out of 7).

5.2 | Prediction of sensitivity

We first established models of grandparents' and parents' sensitivity during the recorded video chats. Based on an unconditional means model with scores nested inside of family (fixed and random intercept only), the ICC was 0.32 for grandparents and 0.07 for parents. We then plotted sensitivity by

TABLE 3 Summary of mean behaviors (SD) as a function of video chat timepoint or in-person session

	VC1		VC2		VC3		In-person	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Infant age (months)	9.64	2.56	12.57	2.84	14.74	2.72	11.90	3.83
Video chat experience	22.00	12.39	30.72	13.34	36.38	15.20	28.60	15.07
In-person contact	8.30	8.45	13.09	14.11	13.85	15.69	10.66	9.94
Grandparent current stressors	8.08	4.02	8.45	3.26	8.63	3.82	-	
Parent current stressors	10.23	3.08	10.72	3.16	9.42	2.51	-	
Grandparent sensitivity (1–9)	6.97 (*n* = 48)	0.63	6.78 (*n* = 47)	0.74	6.95 (*n* = 43)	0.69	7.67 (*n* = 40)	0.66
Parent sensitivity (1–9)	7.31 (*n* = 43)	0.68	7.00 (*n* = 43)	0.64	7.01 (*n* = 41)	0.62	7.50 (*n* = 25)	0.88
Infant valence (1–7)	4.53 (*n* = 48)	0.53	4.51 (*n* = 47)	0.55	4.50 (*n* = 43)	0.45	4.61 (*n* = 40)	0.56

Note: In-person videos could be submitted at any time during the study. In some cases, videos could not be coded for grandparent or parent sensitivity. For example, there were fewer codes for in-person parent sensitivity (n = 25) as the parent was often recording the interaction.

date because we predicted that sensitivity might change as the COVID-19 context changed family dynamics—for example, as the widespread availability of the COVID vaccine in the United States made in-person interactions safer or as spikes in infections caused concern.

Upon visual inspection of the data, we decided to test linear, quadratic, and cubic models of growth to determine the best fit. We determined the best-fitting growth models based on the AIC, as has been done in prior studies (Casalin et al., 2012; Chirwa et al., 2014; Gemignani & Gervain, 2021). The best model was quadratic for grandparents and cubic for parents (See Figure 2, Table 4, and Table 5). That is, for grandparents, sensitivity decreased from the beginning of data collection to the February 1 date and increased thereafter. For parents, sensitivity decreased from the beginning of the study until February 1, remained relatively stable, and later declined again. Including random effects for growth did not improve model fit, so a random intercept was the only random effect retained for both models. A comparison of the log-likelihoods for the chosen growth models indicated that they had a significantly better fit than the unconditional means models (grandparents: χ^2 [1] = 5.43, $p = 0.020$; parents: χ^2 [1] = 3.93, $p = 0.047$).

Next, we incorporated our predictors of interest into the models. Level 1 predictors included an estimate of the child's video chat experience, a current stressors index for the adult whose sensitivity was being predicted, and the sensitivity of the other adult participating in the video chat. The log of the geographic distance (in miles) between the parent's and grandparent's residences was included as a level 2 predictor.

The final grandparent model (Table 4) accounted for 54.8% of the variability in grandparent sensitivity, with 25.2% contributed by the fixed components. Grandparents' sensitivity was lowest at February 1, 2021, and increased thereafter with date ($b_{\text{Date squared}} = 0.01$, $p = 0.050$). Grandparent sensitivity was higher when parent sensitivity was higher ($b_{\text{Parent sensitivity}} = 0.48$, $p < 0.001$). Grandparent current stressors, the child's video chat experience, and the geographic distance between family members were not significant predictors of grandparent sensitivity.

The final parent model, using cubic growth (Table 5), accounted for 33.1% of the variability in parent sensitivity, with 27.5% contributed by the fixed components. Change in sensitivity was smaller around February 1, 2021, and sensitivity decreased as 2021 continued ($b_{\text{Date cubed}} = -0.002$, $p = 0.018$). Parent sensitivity was higher when grandparent sensitivity was higher ($b_{\text{Grandparent sensitivity}} = 0.44$, $p < 0.001$), and when the geographic distance between the parent and grandparent was less ($b_{\text{Log distance}} = -0.06$, $p = 0.012$). Parent current stressors and the child's video chat frequency were not significant predictors of parent sensitivity.

5.3 | Prediction of infant valence

We plotted infant valence both over video chat and in person as a function of age in months (see Figure 2). Based on an unconditional means model with scores nested inside of family (fixed and random intercept only), the ICC was 0.27. Following the same model-building approach used for sensitivity, we tested linear, quadratic, and cubic models of growth to determine the best fit. Although there were no significant fixed effects of infant age, the best-fitting model included random slopes, so we retained linear and fixed effects of infant age. A comparison of the log-likelihoods for the growth model confirmed it had better fit than the unconditional means models (χ^2 [3] = 8.01, $p = 0.046$), although the difference did not meet the traditional threshold for statistical significance.

We then incorporated predictors of interest into the growth model. Given that parent and grandparent current stressor scores were not associated with parent or grandparent sensitivity, we did not include them in our infant valence model. Level 1 predictors included estimates of both video chat

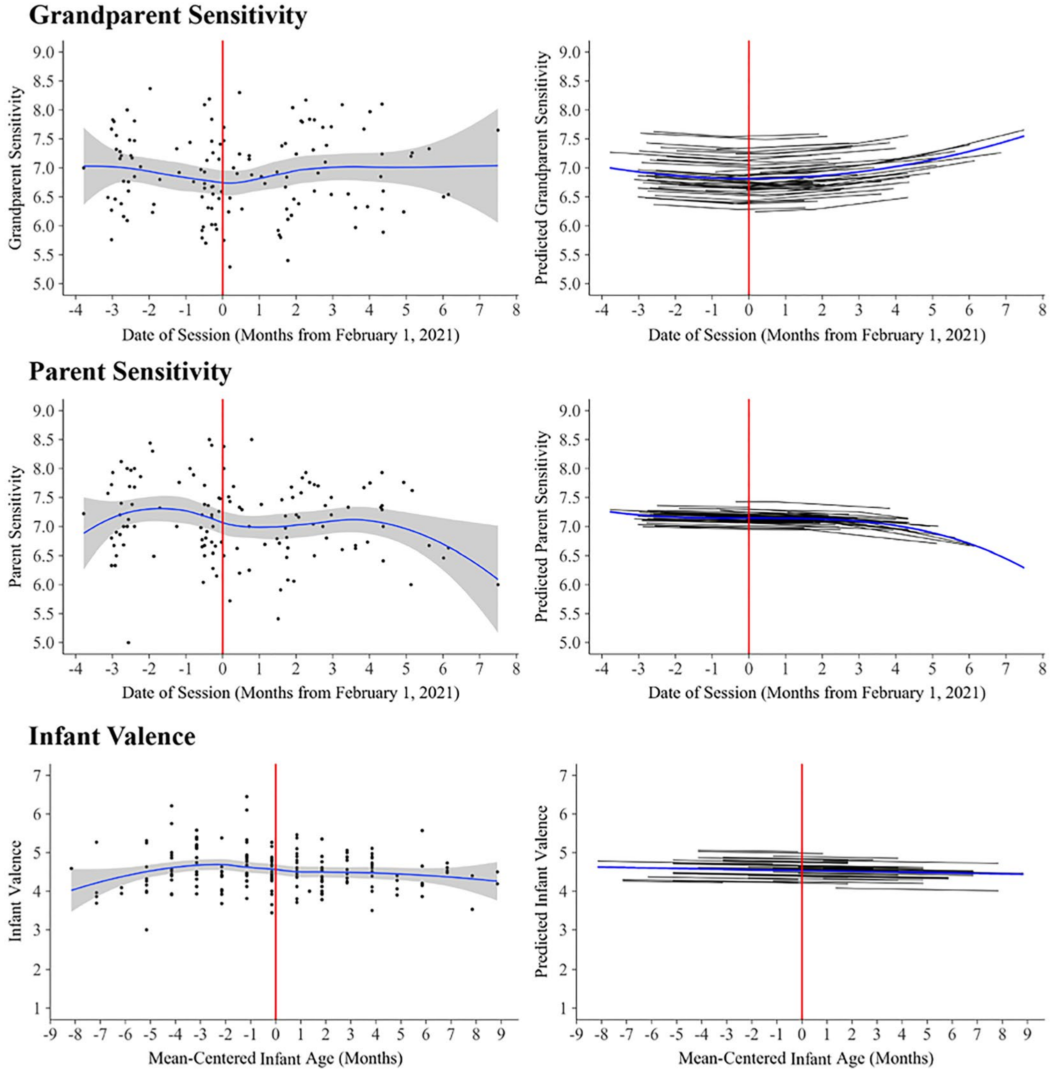

FIGURE 2 Illustration of the raw data and best-fit growth models as a function of time for grandparent sensitivity (top panel), parent sensitivity (middle panel), and infant valence (bottom panel). Top panel. Grandparent sensitivity during video chat only, raw data (left) and predicted fitted quadratic growth model (right) as a function of time with a red line representing February 1. Middle panel. Parent sensitivity during video chat only, raw data (left) and predicted fitted cubic growth (right) as a function of time with a red line representing February 1. Bottom panel. Infant valence both during video chat and in person, raw data (left) as a function of mean-centered infant age in months with predicted fitted linear growth model (right) as a function of infant age with a red line representing the overall average

experience and in-person contact, the sensitivity of the parent and the grandparent, and the modality of the interaction (in-person or video chat). We also tested two interaction terms, one for parents and one for grandparents, to account for whether sensitivity depended upon modality. The log of the geographic distance (in miles) between the parent and grandparent's residences was included as a level 2 predictor, and because families could submit a video of an in-person grandparent–grandchild meeting that occurred before, after, or between their video chats, we included the number of video

TABLE 4 Multilevel models for grandparent sensitivity

	Growth model				Final model			
	Estimate	***SE***	***t***	***p***	**Estimate**	***SE***	***t***	***p***
Intercept	6.81***	0.08	81.96	<0.001	3.12***	0.62	5.00	<0.001
Date squared	0.01*	0.006	2.37	0.020	0.01*	0.005	1.98	0.050
Geographic distance (log)	–	–	–	–	0.06+	0.03	1.84	0.073
Video chat experience	–	–	–	–	0.004	0.004	1.05	0.298
Parent sensitivity	–	–	–	–	0.48***	0.07	6.43	<0.001
Current stressors	–	–	–	–	−0.01	0.02	−0.75	0.45
Num.Obs.	138				127			
SD for random intercept	0.40				0.37			
AIC	277.5				227.6			
RMSE	0.49				0.40			

Note: Dates were centered on February 1 and are reported by month. When comparing fit for these models, please note that the growth and final models were not fit from the same data, as videos in which the parent was not visible did not receive a sensitivity score and were therefore excluded from the final model.

$^{+}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

TABLE 5 Multilevel models for parent sensitivity

	Growth model				Final model			
	Estimate	***SE***	***t***	***p***	**Estimate**	***SE***	***t***	***p***
Intercept	7.14***	0.06	110.49	<0.001	4.46***	0.59	7.56	<0.001
Date cubic	−0.002*	0.001	−2.02	0.046	−0.002*	0.001	−2.40	0.018
Geographic distance (log)	–	–	–	–	−0.06*	0.02	−2.56	0.015
Video chat experience	–	–	–	–	0.000	0.004	0.07	0.956
Grandparent sensitivity	–	–	–	–	0.44***	0.08	5.81	<0.001
Current stressors	–	–	–	–	−0.006	0.02	−0.34	0.733
Num.Obs.	127				126			
SD for random intercept	0.21				0.16			
AIC	257.3				226.0			
RMSE	0.59				0.52			

Note: Dates were centered on February 1 and are reported by month. When comparing fit for these models, please note that the growth and final models were not fit from the same data, as one parent did not complete the emotional distress items at one time point.

$^{+}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

chats that occurred prior to the in-person meeting as well. The interaction terms were nonsignificant, so following other researchers (Judd et al., 2009; Robson & Pevalin, 2016), we removed the interactions for a more parsimonious model. Table 6 provides the best-fitting growth model and final model.

The final infant valence model (Table 6) accounted for 33.5% of the variability in infant valence, with 11.4% contributed by the fixed components. Grandparent sensitivity was the only significant predictor of positive infant valence ($b_{\text{Grandparent sensitivity}} = 0.28$, $p < 0.001$). No other variables were significant predictors of infant valence.

TABLE 6 Multilevel model for infant valence - comparing growth and final model

	Growth model				Final model			
	Estimate	***SE***	***t***	***p***	**Estimate**	***SE***	***t***	***p***
Intercept	4.54***	0.05	93.80	<0.001	4.72***	0.21	22.28	<0.001
Infant age in months	−0.02	0.01	−1.38	0.175	0.003	0.02	0.13	0.894
Geographic distance (log)					−0.007	0.03	−0.26	0.797
Video chat experience					−0.005	0.004	−1.18	0.242
In-person contact					0.000	0.004	- 0.05	0.957
Modality (in-person or video chat)					−0.11	0.12	−0.90	0.370
Grandparent sensitivity					0.28***	0.08	3.67	<0.001
Parent sensitivity					−0.06	0.07	−0.86	0.392
Video chats before in-person					0.02	0.05	0.30	0.768
Num.Obs.		179			128			
SD for random intercept		0.23			0.23			
SD for random slope		0.05			0.09			
AIC		262.8			197.4			
RMSE		0.38			0.39			

Note: The following variables were mean-centered: infant age in months ($M = 12.15$ months, $SD = 3.5$) and parent and grandparent sensitivity.

$^{+}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

6 | DISCUSSION

Throughout 2020 and 2021, COVID-19 disrupted in-person interactions between grandparents and their infant grandchildren. This longitudinal study examined the sensitivity of grandparents and parents during grandparent–grandchild video chat interactions during this time, and whether grandparent sensitivity was related to infants' affective valence during video chat and in-person interactions. We found that grandparents engaged with varying levels of sensitivity with their grandbabies during video chat and that higher grandparent sensitivity predicted more positive infant affective valence, as it does in person (Bornstein et al., 2008). During both in-person and video chat interactions, grandparent sensitivity predicted positive infant affective valence over and above geographic distance. Thus, the effects of COVID-19 disruptions to socioemotional development for infants may be buffered by sensitive video chat interactions. These findings speak to the adaptability and resilience of families during the tumultuous and stressful COVID-19 pandemic and suggest that grandparents can play an important role in creating a supportive “virtual microsystem” for the child. In our sample, the frequency of video chat was much higher than in-person contact for nearly all families.

The present study also showed that both parent and grandparent sensitivity varied across time but that the parent and grandparent patterns differed from one another. Overall, caregiver sensitivity of both parents and grandparents was high in this sample. However, for grandparents, sensitivity decreased prior to February 1, 2021, when vaccines became available for older adults, but increased thereafter. For parents, sensitivity decreased initially and then remained relatively stable until near the end of the study, when it decreased again. There are several potential explanations. As infants' experience with video chat increased, parents may not have needed to be as involved to facilitate the interaction. In addition, as grandparent sensitivity increased, perhaps it reduced demand on the parent. Geographic distance from the grandparent was associated with lower parent sensitivity during video chat, but this was not the case for grandparents, suggesting that when families were separated by long distances, video chat may have supported the grandparent more than the parent. We also found that infant affective valence did not change over time as a function of infant age, prior in-person or video chat contact between the grandparent and grandchild, the parent's sensitivity, or the modality of the interaction (in person or video chat). Rather, in the best-fit model, grandparent sensitivity was the strongest predictor of positive infant valence. These findings demonstrate that even across screens, infants interact with more positive emotion when caregivers are sensitive. We attribute this finding to the importance of sensitive, contingent back-and-forth interactions with social partners for infant positive affect and interpret our findings to mean that, although in-person and video chat interactions differ in important ways, video chat can be an effective medium for sensitive interactions with infants.

Although the self-reported current stressors composite at an individual level was not associated with changes in parent or grandparent sensitivity in this sample, the sensitivity of both adults was associated with fluctuations in the global stressor of the pandemic itself. Furthermore, each adult's sensitivity toward the infant predicted the sensitivity of the other adult. Although much research on sensitivity in families has focused on children and parents during childhood, here we see the link between the sensitivity of grandparents and parents and how grandparents' sensitivity is associated with the affective responses of their grandchild. This finding underlines the importance of considering how parents are supported by other adults as an important context for infant development (Neuhauser, 2018).

The present findings replicate prior research indicating that contingent mother–child social interactions predict child outcomes (Bornstein et al., 2008) and extend our knowledge base in two exciting directions, to other relationships and virtual interactions via video chat. First, the data provide additional insight into developing grandparent–grandchild relationships from a very young age, demonstrating that grandparent sensitivity is closely linked to infant affective valence in a basic pattern similar to that observed in parent–child dyads, both in person and via video chat (Braungart-Rieker et al., 2001; McClure et al., 2020). In a video chat context, where infants cannot easily engage on their own, parents scaffold a dyadic interaction between the infant and their across-screen partner. Our findings provide an important window into grandparent–grandchild relationships in infancy, whereas much of the existing literature examines these important relationships during later childhood and adolescence (Dunifon, 2013). Second, the present findings demonstrate that higher grandparent sensitivity on video chat is associated with more positive infant affective responsiveness. Several studies have reported on the importance of social contingency in video chat for the formation and maintenance of social relationships (Myers et al., 2017; Tarasuik et al., 2011, 2013); however, except for a few notable exceptions that motivated this study (McClure et al., 2018, 2020), most of the existing literature has used experimental video chat designs in the lab or in the home. Laboratory studies suggest that due to social contingency over video chat, younger children may view a sensitive person on screen as a potential partner for play and interaction (McClure et al., 2020; Myers et al., 2017; Strouse et al., 2018; Troseth et al., 2018). Young children detect whether a virtual partner provides information about the world that is accurate, timely, and reliable (Koenig & Harris, 2005; Roseberry et al., 2014). The present semi-naturalistic longitudinal study builds on the McClure et al. (2020) laboratory study's findings that an adult's global sensitivity is more closely related to infant positive responsiveness than the modality of the interaction. Our study examines real-time sensitivity while extending this finding both longitudinally and across modality.

The majority of studies on sensitivity and infant outcomes have focused on mothers, and more recently fathers, but infants do not develop in isolated, in-person dyads. As Bronfenbrenner (1979) suggested, children develop in dynamic family ecologies in which the relationships between their caregivers may play a less visible but important role. COVID-19 resulted in a fundamental shift in intergenerational family relationships, as pandemic-era infants had fewer face-to-face interactions with their grandparents and many families turned instead to video chat (G. Brown & Greenfield, 2021). Grandparents in our sample readily adapted interactions with grandchildren to fit within this virtual environment, and infants participated with positive affect. Our findings suggest that advancing video chat technology in the 21st century has created the possibility of grandparents' influence on children within a "virtual microsystem."

6.1 | Limitations

The limitations of our study include gender homogeneity and lack of racial, cultural, and socioeconomic diversity. While our recruitment materials recruited parents and grandparents of any gender, our final sample only included grandmothers and mostly mothers. Prior studies suggest that adult gender and infant sex are associated with differences in grandparenting as well as both sensitivity and affect in dyadic interactions (Mueller & Elder, 2003), so additional studies with fathers and grandfathers are needed (e.g., G. L. Brown et al., 2012). Furthermore, our sample primarily included well-educated, affluent, White families, but the pandemic has had a disproportionate impact on families with fewer financial resources, families of color, and immigrant families (Fisher et al., 2021; Karpman et al., 2020). The relationship between socioeconomic and educational factors and grandparent–grandchild closeness is complex. For example, grandparents with lower levels of education may spend more time in close proximity with grandchildren (King & Elder, 1998). In addition, lower-income families, rural families, and families of color may have reduced access to broadband services (Katz et al., 2017), and video chat with lower connectivity might include technical disruptions that could limit grandparents' ability to engage sensitively with an infant.

Finally, this study focused on nonresident grandparents, but grandparenting is highly variable in the United States (Mueller & Elder, 2003). To understand the experiences of a broader range of families as they have used technology to adapt to geographical distance, additional family factors should be considered in future studies, including differences related to custodial grandparents, single-parent households, the presence of siblings, and socioeconomic and cultural diversity.

6.2 | Future directions

Culture will likely play a role in how families use video chat to support relational health and infant development. In a recent cross-cultural study, Lavelli et al. (2019) found that emphasis on the importance of mother–child face-to-face interaction may not be culturally universal. Infants in cultures that place less emphasis on face-to-face interactions may experience video chat differently. Additional research with the current data set is ongoing to examine family cultural practices during video chat.

Questions remain about core mechanisms and measures of infant emotional development (Pollak et al., 2019), and it is important to study these interactions at a number of time scales (Silk, 2019). Here, we used mean affective variables as coded in 30-s blocks to obtain a holistic view of semi-naturalistic interactions across multiple time points, but we plan further examination using a finer time scale to further understand social contingency and infant affect during virtual interactions (e.g., moment-to-moment triadic synchrony during an in-person reunion).

Furthermore, in the current study, we used Zoom to record unsupervised interactions over multiple time points, providing a cost-effective and minimally intrusive data collection method that can be used in future studies of infant emotional development within family relationships. Future studies could also include experimental studies that measure other dimensions of emotional development, including arousal and temperament.

Video chat did not disrupt sensitivity, which may provide valuable guidance for practitioners providing telehealth services. Research on telehealth during the pandemic (Kronberg et al., 2021) suggests that video chat has great potential for use in intervention settings. Video chat may provide a novel way for practitioners to support families in distress and may also provide additional support for custodial grandparents by improving infant connections with separated parents.

6.3 | Implications

COVID-19 provides a unique context for infant development, but geographical distance between infants and close caregivers is common. Each year, millions of young children develop at a distance from their caregivers due to divorce, incarceration, immigration, deployment, or illness (Batalova et al., 2021; Berman & Daneback, 2020; DOD, 2012; Scommegna, 2014; Sykes & Pettit, 2014). No matter the reason for family separation, our findings suggest that video chat can support sensitive infant–caregiver interactions that bridge these distances. Given current inequities, economic policies and cultural values that support equitable access to technology will be of critical importance during the remainder of the COVID-19 pandemic and beyond.

In summary, we found that intergenerational triads can engage sensitively and responsively over video chat, that grandparent and parent sensitivity during video chat are associated with one another, and that higher grandparent sensitivity is associated with positive infant affective valence regardless of modality. These findings suggest the enduring power of sensitive caregiving to support infant development, even during a pandemic and across screens.

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