



Article

Shifting Design Perspectives: Touch, Co-Location, and Sharing Objects during the Pandemic

Kimiko Ryokai ^{1,*} , Nicole Marie Bulalacao ², Sandra Jacobo ², Prasad Boradkar ³ and Kelly Dobson ³

¹ School of Information, University of California Berkeley, Berkeley, CA 94720, USA

² School of Education, University of California Berkeley, Berkeley, CA 94720, USA

³ Google, Mountain View, CA 94043, USA

* Correspondence: kimiko@berkeley.edu

Abstract: HCI has explored a variety of technologies to support human-to-human touch through simulating or mediating the feeling of touch over distance. Restrictions in activities involving touch, close contact, and physical proximity due to the COVID-19 pandemic have made it more pertinent to understand and investigate the goals, opportunities, and limitations of technologically mediated touch. We conducted an exploratory interview study with 18 participants across the United States in April and June of 2021 to understand how the COVID-19 pandemic has changed people's attitudes towards engaging in touch, being co-located, and sharing physical objects. We observed four themes: new efforts to evaluate safety, new preferences for physically co-locating without touch, technology solutions amplifying separation, and a newfound appreciation for human touch and touch-adjacent activities. These results suggest that future touch technologies may need to shift focus from simulating human touch convincingly to allowing for interactions that incorporate these emergent sensitivities to safety and preferences for physical co-location.

Keywords: CCS concepts; human-centered computing; human–computer interaction (HCI); HCI design and evaluation methods; touch; physical co-location; objects; haptics; interview study; COVID-19 pandemic CCS concepts



Citation: Ryokai, K.; Bulalacao, N.M.; Jacobo, S.; Boradkar, P.; Dobson, K. Shifting Design Perspectives: Touch, Co-Location, and Sharing Objects during the Pandemic. *Multimodal Technol. Interact.* **2022**, *6*, 74. <https://doi.org/10.3390/mti6090074>

Academic Editor: Cristina Portalés Ricart

Received: 21 June 2022

Accepted: 4 August 2022

Published: 31 August 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

"It has been so challenging you know. I've had friends get divorces. I've had a friend, you know, have a miscarriage. I've had, you know, people lose a parent. Just so many people coming over with things were like, the only normal reaction is to hug. Someone showing up and being like, 'I just had my cat, he's dead, what do I do?' And I'm like, 'I can't hug you and I can't go in your house. I can talk. I can talk you through this' but, like that, just a lot of, a lot of times, where it seems like the human reaction is to physically reach out to someone. And not being able to do that has been really challenging." (Participant #8, age 34–45)

In the United States, like in many countries, the COVID-19 pandemic has disrupted how people gather, communicate, and connect. This disruption is due to physical distancing measures enforced in early 2020 to reduce the spread of disease. The overall result of prolonged physical distancing was a shift in activities and attitudes towards human-to-human touch and physical proximity. This shift is most acutely felt in activities in which people routinely connect with those outside of their households, such as family and friends. Initially, it was believed the physical distancing measures were temporary. However, the spread and variations of the SARS-CoV-2 virus and resulting physical restrictions in activities involving touch, close contact, and physical proximity continue to linger more than two years later.

Since the 1990s, HCI communities have explored innovative technologies that support human-to-human interaction by simulating or mediating the feeling of human touch

over distance (e.g., [1–3]). The premise of such touch technologies is that our need for human touch can be fulfilled even when we cannot be in proximity with our loved ones. Now would be the opportune time for HCI practitioners to deploy such promised touch technologies. However, the reality is that these technologies have not met people's needs, and there is no evidence of their widespread use during the pandemic years of 2020–2022. Although touch technologies may perform well in lab settings, even the most established designs (e.g., [1]) have not found their footing in the mainstream. This may be partly due to limited access to technology, but it also may be due to an underdeveloped understanding of touch among HCI researchers, particularly in current pandemic times. It remains an open question as to how touch attitudes and needs have shifted due to physical distancing measures enforced during pandemic times, and its implications for the design of touch communication technologies.

We conducted an exploratory interview study with 18 participants across the United States in April–June 2021, the year after physical distancing measures were first enforced and around the time when the first doses of the COVID-19 vaccine were distributed nationally. The study's goal was to identify activities people had engaged in regarding touch, physical co-presence, and sharing objects; and changes in activities or attitudes before and during the pandemic. By understanding people's activities given the "new norms" imposed by the pandemic, our goal was to examine innovation opportunities in touch technologies. Interestingly, we discovered that any currently existing forms of technologically mediated communication might be unlikely to fulfill the need for human-to-human touch. Worse, our current technological solutions seem to amplify the feeling of missing human-to-human touch. We observed four main themes regarding attitude and activity changes in relation to touch, colocation, and sharing of physical objects during the pandemic.

The first theme refers to new efforts people undertake in **evaluating safety** in human-to-human interactions. Participants developed ways to mentally and physically safeguard themselves against COVID-19 in social situations. These ranged from using spatial information (e.g., "triangulation" in an elevator ride with strangers) to social media to quickly evaluate how to approach other people in person or participate in an event safely. This layer of caution to judge the safety in proximity with another person varies considerably based on the individual's age, health conditions, living situation, etc. Moreover, this layer dynamically changes with the ebb and flow of infection (e.g., omicron variant surge) and vaccination rates. Touch technology in HCI must keep such uncertainty and awkwardness around safety brought on by the dynamic situation in mind.

The second theme includes new **preferences for co-locatedness without touch**. Participants preferred non-technologically mediated means of gathering, such as meeting at a park to have lunch and separating 6 feet apart or parking their cars beside each other for a chat over coffee. When faced with physical touch limitations, participants shared they appreciated being physically collocated with others without any technological mediation, even if they could not directly touch each other. Our findings suggest a new consideration for touch technology, shifting from focusing solely on touch to paying attention to other sensory elements of physical colocation.

The third theme relates to how **current technological solutions amplify the feeling of missing human-to-human touch**, which includes an acute awareness of an inability to communicate care through physical reach (e.g., patting someone on the back, giving a hug to a friend in distress) while in conversation with family and friends, inability to physically participate in a family dinner over Zoom (e.g., "pass me the dish"), and inability for spontaneity with others (e.g., going arm in arm with a friend). While HCI thus far has focused on mediating touch between intimate couples, participants in our study missed touch with non-romantic friends, family members over multiple generations, and even strangers. The forms of physical touch the participants missed were enormously varied, spontaneous yet deeply meaningful, precise yet nuanced in their dynamic situations. Our research points to a need for touch technology research to move away from asking whether

intimate emotions are felt accurately between a predetermined couple to a more nuanced understanding of touch felt through our bodies with broader range of relationships.

The fourth theme highlights participants' new **appreciation of human connectedness**, such as the momentous feeling of experiencing touch after prolonged physical isolation. Our findings show that people have developed a profound appreciation for genuine human-to-human touch during the pandemic. As such, people may choose to wait for the moment to engage in physical touch rather than seeking technologically mediated simulations.

Together, these themes highlight the pre-pandemic assumptions previous HCI touch technology research was based on and point to new approaches to designing experiences with touch technologies in times of physical distancing. Additionally, these findings make visible the novel ways people deal with the tension of minimizing risk while maximizing ways to *feel touched and connected*, and serve as inspiration for touch-based designs that consider shifts in attitudes about touch brought forth by COVID-19 precautions.

The following study serves to (1) contribute a qualitative understanding of the impact the pandemic has had on social connection, with a focus on human-to-human touch, physical co-location, and sharing physical objects, (2) take a fresh look at the current HCI touch technologies, considering the recent shift in people's attitudes towards touch and touch-adjacent activities, and (3) suggest new approaches and considerations for future touch technology research.

2. Background

Touch implies shared time and space, requiring direct physical interaction (shared material or body and time) and co-location (shared space). As a result, physical contact, mediated by the sense of touch, is an essential part of social communication, providing the experience of togetherness and social presence [4–6]. Furthermore, touch consists of a shared sensory experience between individuals representing a privileged channel of communication, conveying immediate socio-emotional meanings and reinforcing social bonds [7]. In line with HCI's commitment to examining novel ways in which humans interact with computers, HCI researchers have explored a multitude of ways technology can simulate social touch when touch is limited or unavailable. Given the physical distancing measures during the pandemic, reviewing the types of social connection touch technologies aim to support seems particularly relevant.

2.1. Touch Technology in HCI

An initial step towards exploring human–computer interaction engagement with social and physical environments [8] began in the late 1990s, with HCI's turn to *embodiment* [8,9] from the previous era primarily focused on graphical user interfaces (GUIs). From this shift emerged tangible user interfaces (TUIs) built around people's familiarity with the physical and social world. Early touch technologies were TUIs supporting human relatedness, such as connectedness, intimacy, love, belonging, closeness, or togetherness [10,11] through the physicality of devices. For example, *inTouch* [1], one of the earliest designs leveraging haptic technology, supported physical touch over distance using actuated wooden rollers that simulated the rubbing of two palms designed to connect two people. Subsequent TUI research aimed to simulate a sense of being hugged over a distance, *Hug over a Distance* [2] and *The Hug* [12], or enabled remote couples to communicate with each other via physical kiss/touch, *Kiss communicator* [13]. While these early prototypes inspired new design possibilities beyond desktop settings to evoke human relatedness via simulated touch over distance, most of these systems were not evaluated through empirical studies.

HCI researchers have recently evaluated the sense of mediated touch in social communication through haptic technologies. For example, *TaSST* (Tactile Sleeve for Social Touch) [14], a touch-sensitive vibrotactile arm sleeve, explored how couples discerned between types of touch for different emotions (e.g., stroking for love, squeezing for fear). Obrist et al. [15] demonstrated a mid-air haptic system where the participants distinguished non-arbitrary mapping of emotions through haptic stimuli sensed through the air. With

the advancement of micro actuators, using haptic technology on smartphones also became increasingly possible. For example, *Bendi* [16] supported remote touch via a flexible oversized skin extension of a smartphone that curled up and down, as if the partners' fingers were curled. *Poke* [17] is a phone-based interface with an inflatable surface to give a sensation of one's cheek being poked during a phone conversation. The researchers evaluated how couples express and understand emotions over distance (e.g., participants used soft touches for positive emotions, while negative emotions were expressed through hard, fast, and continuous touches). Most recently, *Touch without Touching* [3] has explored a smartphone-based system to allow two individuals to engage in a simulated handshake without touching the other person. These touch technologies, studied in a laboratory setting, serve to promote connection through emotional expression, simulating gesture, or simulating touch. Haptic technologies have also been applied to create three-dimensional interactive surfaces built on our sense of touch. For example, *inFORM* [18], a shape-shifting surface allowed two collaborators to physically share their gestures and objects. This signaled a new approach to physical telepresence based on shared workspaces, with the ability to capture and remotely render the shapes of people and objects. *inFORCE* [19], using similar technology, is a bi-directional force shape display for haptic interaction that allows remotely located users to physically touch and manipulate objects.

Generally, conducting touch technology research in HCI requires a commitment between two parties, typically in romantic or intimate relationships, who agree to using the technology during the research period, which has implications for the types of human connections explored. Moreover, touch technology research is resource intensive, requiring special hardware and software not yet readily available for home use, which limits the generalizability of the findings. As Hassenzahl et al. describe it, despite seeming obvious, "the mediation of physicalness is one of the most challenging within the field of designing for relatedness" [10].

2.2. Pre-Pandemic Design Assumptions

Regarding past HCI research, it is important to highlight the reasons why shifts in preferences around touch and technology from the pandemic should be considered in future technology development for mediated touch. First, HCI researchers thus far, have explored a variety of haptic systems that use touch simulation, generally to demonstrate the non-arbitrary mapping between a set of emotions and haptic descriptions (happy, sad, excited, afraid, etc., e.g., [14,15]). However, the psychological benefits of such simulated touch in the context of interactions are less clear.

Second, most of these prototypes were evaluated in lab settings or controlled scenarios between two participants in a romantic relationship, or study participants who agreed to participate in such an activity. In contrast, under physical distancing measures and travel restrictions during the pandemic, different types of relationships (e.g., non-romantic friendships, family members over multiple generations) have additionally suffered from an inability to see or touch one another in a variety of personal contexts [20–22]. Therefore, touch technology research may benefit from a new understanding of what is missed due to the pandemic restrictions regarding interpersonal touch.

Third, many of these touch technologies seem to have been built under the assumption that missing touch was a temporary feeling between two individuals; for example, when one partner within a couple is on a business trip, etc. [2,13,16]. During the current COVID-19 pandemic, we experienced an unprecedented length of limited physical contact. Recent studies in psychology have shown interpersonal touch deprivation during the pandemic was associated with greater loneliness and anxiety, and people craved touch interactions, underlining the importance of feeling the physical presence of others for psychological well-being [7,20]. As such, HCI researchers need a better understanding of the aspects affecting human touch and the context in which people sought human touch during the pandemic.

Finally, our attitude towards communication technology has changed dramatically since the beginning of the pandemic due to prolonged use of communication tools for both work and personal communication, as described by research on *Zoom fatigue* [23], *digital detox* [24], and *turn to offline* [25]. According to the Pew Research Center findings, 71% of adults say text messages or group messaging apps have helped them at least a little with staying connected with family and friends during the pandemic. Additionally, 68% of Americans say digital interactions have been helpful—but not a replacement for in-person connection. However, among those who have used video calls during the outbreak, 40% feel fatigued or worn out, at least sometimes, from time spent on these calls [26]. Given the aforementioned touch technologies were designed before the pandemic, when people used less computer-mediated communication with their loved ones, the current research explores new activities and communications preferences regarding touch brought on by the pandemic.

3. Methods

The COVID-19 pandemic presented an opportunity to explore how people used tools and strategies to mediate touch while being physically separated without the artificial scaffolds of a controlled lab setting. Understanding preferences for touch and social connection are relationship and situation dependent [27], we designed a semi-structured interview to capture a nuanced and contextualized account of the strategies used to organize for touch and colocation, the situations in which such strategies were used, how the participants felt about the outcomes of such strategies, and participants' shifts in touch preferences from prolonged physical distancing.

3.1. Recruitment and Participants

The research team recruited participants by distributing a recruiting announcement and screener survey through local networks, listservs, and Facebook communities. Participants were selected based on two criteria: (1) those who regularly kept in touch with partners, friends, and family that lived outside of their household using a digital communication tool over the years 2020 and 2021, and (2) those who reported attending at least one virtual celebration/event with their loved ones that they had attended in person in previous years. These selection criteria ensured participants had some desire to gather with family and friends, even if it was not in person, and had prior social experiences in intimate physical gatherings to serve as a comparison against remote ones.

Participants interviewed ($n = 18$) described themselves as 74.0% (13) female, 21.7% male, 4.3% non-binary or preferred not to state; 30% were married, 43% single; 61.8% lived in urban or close to urban centers (31.8% suburban); 90.1% had completed a 4-year college degree or beyond; 21% lived alone, 25% lived with one other person, and 54% lived with two or more people. The ages ranged from 22 to 85 years (Mean: 37.5, SD: 16.6). All participants resided in the United States at the time of the interview, and the small sample size did not reflect the general population of the US. Nevertheless, the participant pool generated diversity of touch and touch-adjacent experiences that we explored in depth.

3.2. Questionnaire

Before the interview started, the participants received an email describing the nature of the study and a digital Qualtrics questionnaire. To understand participants' touch preferences and strategies, we included questions regarding their agreement with initiating physical affection, enjoyment of physical presence, missing physical presence and affection, and initiating messages in close relationships.

The results of the pre-interview questionnaire (Figure 1) shows most participants (15, 88%) enjoyed physical presence and moments of physical affection (i.e., greetings, hugs). In parallel, most participants (15, 88%) missed physical contact with other participants.

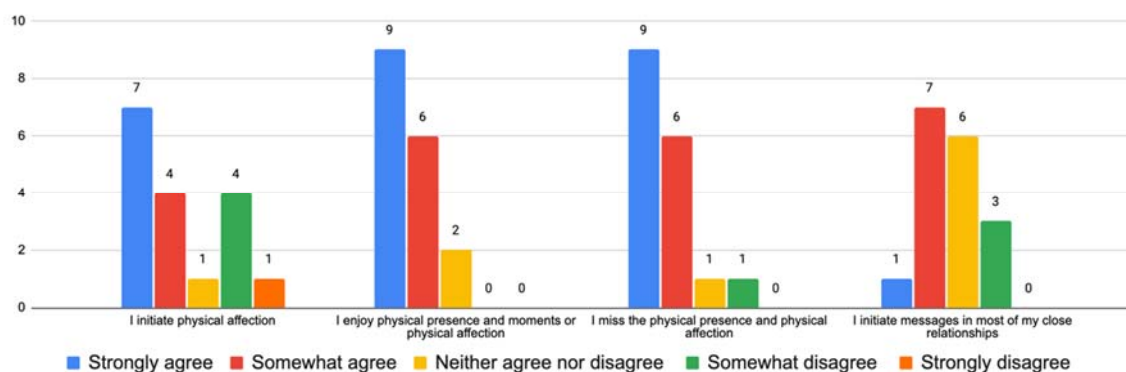


Figure 1. Distribution of physical touch and communication behaviors.

3.3. Interviews

Our goal in this study was to elicit stories from the participants regarding their personal experiences and attitudes towards human-to-human touch, co-location, and sharing physical objects during a pandemic. We intentionally avoided any workshop exercises using physical materials (c.f., [28,29]), so our participants' oral stories focused on their felt experiences. Therefore, we did not engage in any activities involving brainstorming future imaginary scenarios with new materials. To understand how participants experienced touch during the pandemic, we conducted 60 min semi-structured interviews from April 2021 to June 2021, a time involving increased use of digital technologies to connect and remain in communication with others, and reported experiencing general Zoom fatigue [22,23]. First, participants were asked about their practices and attitudes towards touch, colocation, and sharing objects before and after COVID-19 physical distancing measures. Second, participants were asked how they coordinated such experiences with and without the use of technology, their experience with these strategies, and any modifications they would want to make to their arrangements to improve their experience.

3.4. Researcher Positionality

This study used a qualitative approach to interpreting interview data using thematic analysis that forms the basis of the discussion [30]. While there is no singular or correct pathway to an interpretive approach, these types of qualitative analyses can suggest a reality that consists of people's subjective experiences or interpretations of the world [31]. This method of analysis can also suggest a way to understand meaning or try to make sense of textual data through semi-structured examination of the phenomenon [32].

Using an interpretivist lens, it is therefore important to acknowledge our positionality as academic researchers working at an academic institution and living in the San Francisco Bay Area during the period of social distancing in early to mid-2022. The authors were working at home, using various forms of communication to connect with colleagues and social circles. This may have given our team an empathetic viewpoint towards participant responses about lack of touch, Zoom fatigue, and experiences using technology to connect with others, because each member of the team lived through similar circumstances. Being both researchers and people living during physical distancing puts us in a unique position as close observers and interpreters of shifts in touch and communication activities.

3.5. Data Analysis

Responses and interviews were transcribed and then analyzed using an inductive-thematic analysis procedure [33] to identify meaningful experiences captured in Atlas.ti software. The research team used memos to share interesting points in the interviews. The researchers analyzed overall patterns and emerging themes based on the memos, responses, and transcriptions.

The initial read of the transcript involved highlighting meaningful texts [30] the researchers considered important moments. Meaningful texts consisted of quotes in which

participants described feelings or changes around sharing, co-locating, or touch. This resulted in data roughly clustered around physical, in-person activities, digitally mediated activities, and shifts in activities before and after the pandemic. After an initial round of coding, comments were inserted with initial thoughts and ideas, suggesting important behaviors or ideas that were worth discussing. This process was repeated using the codes as a guide to determine whether more meaningful moments fit within the codebook parameters, or whether additional codes needed to be added.

The researchers prioritized units of text describing strategies of touch or touch-adjacent activity and an interesting facet of people's felt experiences with such strategy. This led to codes such as "hesitation/effort", "anxious", "trust", "spontaneity", "solitude", etc. Researchers refined the coding schema by grouping those codes by similar sentiment, which often concerned feelings around community (or lack thereof), safety and connection (or lack thereof) around touch activities, and effort to overcome time and space issues. This led the team to categorize codes around groups "safety", "communication strategies", "events", "physical co-location", etc.

Then, the research team organized the codes into meaningful groups, creating an initial schema of themes and subthemes drawn from connections amongst similar code groups. Eventually, codes were clustered around safety concerns, sentiments about experiences with technology, and sentiments about experiences without technology across touch, co-location, and sharing activities. Researchers iteratively reviewed and revised the coding schema, ensuring data were grouped coherently within themes and ensuring distinction between themes until agreement between coders was reached. This involved reading transcripts multiple times until theme saturation was achieved.

Once a satisfactory map of themes, subthemes, and codes was created, researchers iteratively refined and named themes until they reached a consensus on how to accurately describe the essence of each code group (Figure 2).

THEMES	CODE GROUPS	CODES
New efforts to evaluate safety	Co-location	affordances, feelings, constraints, public space, meeting in person, immersive experiences, separating personal space, outdoor space, outdoor dining, physical presence, indoor safety
	Communication strategies	method, maintaining connection, changes, letter writing, photos
	COVID	COVID, vaccination
Preference to co-locate without touch	Events	in-person missed events, virtual events, life events, special occasions
	Relationship type	family, friends, strangers, mom, kids, romantic partner, selected loved ones, daughter, son, pet
	Safety	proximity, touch, face-to-face, anxious, food, space, ventilation
Technology solutions amplifying separation	Shared Objects	feelings, safety, changes, affordances, constraints, library, pictures, protective coating, serving utensils
	Technology	constraints, affordances, apps (zoom, facebook, facetime, skype, WeChat, WhatsApp), directing gaze, future technology, phone, group chat, tablet, texting, virtual spaces
	Timing of interaction	spontaneity, timeliness
A newfound appreciation for human touch	Touch	orientation, changes, form of communication and care, form of connection, hugs: Increased significance, no-tech-use, no-tech-adaption, constraints, need, touch high-touch, low-touch, culture
	Well-being	happiness, mental health, social interaction, stressor
	Others	hugs, food, changes in activity, community, solitude, hesitancy/effort, synchronous activities, physical mail, comfort, gift, trust, emotion, travel, back to normal eventually?, physical activity, culture, sharing perspective, appropriateness, wish you were here

Figure 2. Four themes derived from organizing codes into code groups.

To analyze the codebook the researchers examined interrelated *chunks* of text in relation to the research questions and hypotheses. This approach legitimized the analysis and assisted in the process of interpretation [30].

4. Findings

This section reports on the key themes and illustrative data excerpts. Quotes are reported as Q# for the interviewer and P# for participants. Four key themes emerged based on this in-depth analysis of the 18 participant interviews and questionnaires.

4.1. Evaluating Safety in Face-to-Face Interactions

Social touches, such as hugs and handshakes, are common means of welcoming someone into one's personal space [34]. However, due to COVID-19, these social touches posed a safety risk and had to be re-thought (e.g., elbow bumps) or abandoned altogether. Participants described that changing how one approaches and welcomes another person due to safety concerns felt unnatural. As one participant over the age of 80 described:

"I was with my son walking on the beach. We met a friend of his, and I said, 'Oh, Hi' and I immediately stick out my hand and he shakes it down immediately. And I said, 'Oh, we're not supposed to do that.' I don't know, I believe, old habits are hard to break . . . These were imposed rules, [but] safety is important. My age is important for that because I was in the highest risk area. So, obviously, my main goal was to get through it alive."
(P6, age 80–90)

Here, we can see the participant struggling to balance safety, especially due to her advanced age, and ingrained habits such as handshakes that initiate closer connections with others. A mundane gesture now presents a new situation in which the participant must second guess her threshold of risk to welcome a distant acquaintance through touch.

While all participants talked about their safety concerns related to COVID-19, how they acted as a result varied greatly depending on their age, health, living situation, etc. Some were highly vigilant, particularly those of advanced age, while others were more relaxed, and many fell anywhere in between depending on the situation. Participants indicated safety as a primary factor in deciding how to engage with another person and developed implicit ways to mentally evaluate the personal safety and risk of gathering and touching others.

When asked about changes in touch or co-location brought on by COVID-19, participants mentioned feeling awkward having to find out if friends and family engaged in risky behavior. Some reported asking friends and family about their recent activity before meeting with them (e.g., if they have traveled, taken public transportation, gone out with friends to bars, etc.). Others reported using social media indicators such as Facebook posts or "vaccinated" digital stickers to determine vaccination status. As one participant describes:

"So I checked social media every so often. If someone posted that (status), I would remember that. So it's like when I see somebody, I would 'Oh, did he or she like, post whether they're vaccinated on social media?' If yes, that would be a green light to go. So weird, but I think most of the people, they would post their status of vaccination. And if not, I would say that I would, like, just ask them on social media like before we get together. Like, this week I'm going to see another friend. Like, this Thursday, so I just asked her, 'Did you get vaccinated?' And she said yes. Okay, everybody's happy."
(P17, age 18–25)

Like so many others, this participant felt a sense of extra effort and awkwardness in using various information sources to decide whether or not to attend an otherwise mundane event or to be near another person, creating tension between the desire for connection and the need to be safe. Even when people decided it was safe to visit a loved one face to face, tension persisted. Participants mentioned how approaching a loved one to touch or gather led to moments where mismatched expectations about touch and safety became apparent.

“You know my mother still had to pick me up at the airport . . . She wants to hug me after I get off the plane, you know. She wants to talk and not wear masks and stuff like that. And like, I was wearing my mask in the car and my mom grabbed my hand and she was like ‘You don’t have to wear that right now’, and I was like, ‘Dude, why not?’ You know? Like. I don’t know. You know, like she was just like ready to get back to a sense of normality and like ready for it to feel back to normal.” (P15, age 25–34)

Here, the concern for safety and connecting with a parent are in tension, which results in a confrontation. The participant, who did not feel that things were “normal” wanted to keep safe by wearing a mask. However, the mask became an unnecessary barrier for the parent, hindering connection with her child. This instance serves as a reminder that safety precautions present themselves as being in direct conflict with the normal praxis of connecting with others.

Even when friends and family were aligned regarding safety and contact protocol, there was still uncertainty around how comfortable others felt being in the same space. Respondents mentioned having a pronounced awareness of personal space when near friends and family.

“Most of my friends are kind of like in the same places as me where we have, like, we’re all pretty careful and so we’ve been, like, I feel like they’ve been doing the same thing that I’ve been doing, which is just kind of like always having, like, an awareness of, like, a bubble around you that you’re trying not to get into anybody’s bubble and trying to have any of, any other people come into your bubble. So I feel like we’ve, for the most part, like the couple friends that I’ve seen outside, we’ve had that same, like, awareness.” (P14, age 35–44)

This respondent, like many others, had an awareness about their friends’ sense of “comfortable distance”, and felt safe in a proximal space with friends who shared this same awareness. This example might demonstrate that people who prioritize safety are willing to gather with friends and family who display a congruent awareness about personal “bubbles”.

On the other hand, the following respondent shared a strategy for feeling safe in a public space with strangers:

“If I’ve had a doctor’s appointment, I definitely feel like there’s kind of like a mental calculation that I do to, if there’s a bunch of people, I try to figure out, like where do I triangulate myself to be the furthest distance from, like all of them that I can. I’m not sure how permanent that is, like maybe, that’s something that will stick around after the pandemic, or maybe it will, like gradually disappear? I’m not sure.” (P12, age 35–44)

This respondent describes a sentiment shared by many that emerged when people entered public spaces and could not determine how safe each person was. The inability to assess the level of safety leads to new efforts to strategize how one could keep safe in a given situation (*“where do I triangulate myself to be the furthest distance from, like all of them”*). It perhaps creates a heightened level of uncertainty in public spaces because strangers present elevated health risks just by standing close to one another.

Reflection on HCI Touch Technologies

Generally, participants were not familiar with communicating safety concerns in advance of face-to-face situations or dealing with contentious moments in situ. In addition, safety concerns towards touch and co-location varied significantly based on the participants’ age, personality, health conditions, living situations, etc. As touch and face-to-face interactions are reciprocal in nature, when there is a mismatch between two individuals’ expectations towards touch and safety, there is an unsettling awkwardness, even among family members and close friends. This complex layer of caution and awkwardness through which people must judge whether being physically close to another person or touching the person is safe is a new assumption we must consider when designing touch technologies.

HCI research prototypes such as *Touch Without Touching* [3] seem to directly address this safety issue by allowing users to shake hands through paired smartphones without physically touching one another's hands. However, the researchers have yet to conduct any "in-the-wild" [8] evaluation of Touch Without Touching, as it is currently a tethered prototype functioning only in a lab setting. In the meantime, we question such technology's practicality in the wild. Our interview study shows that people encounter diverse forms of touch beyond handshake in various situations with family members, friends, and strangers. Moreover, touch encounters are spontaneous and unpredictable. In a situation where one person sticks out a hand to greet, would most people be comfortable or willing to reach into one's pocket to grab a smartphone (or any other touch devices) and ask the other person to shake hands through the corresponding device instead? **HCI researchers must reconsider the pre-pandemic assumption that pairs of people are always in agreement and willing to replace their human-to-human touch with one that is felt through a set of devices, even in the interest of staying safe.**

Given the uncertainty and tension, people hesitated to engage in physical touch, even with their loved ones, and it was often difficult to communicate such mixed emotions in situ. "Am I accepting hugs? Not accepting hugs? What is a comfortable range of physical proximity with others?" These questions raise new design challenges such as, "Might there be an opportunity for design that helps people reflect on the tension between their own need for safety and human connection? Might there be an opportunity to design a new forum to express one's preference for human-to-human interactions but implicitly on social media or implicitly display touch preference on one's clothing such as color-changing wearable fabric [35]?" Designs that honor such ambiguity and "thwart any consistent interpretation" [36] may be increasingly pertinent.

4.2. New Co-Locatedness without Touch

The second theme that emerged was participants describing new co-locatedness without touch, and the importance of such space given the limitations posed by COVID-19. The participants expressed their desire to be physically together, even when they cannot physically touch each other due to their experience of "technology detachment and cleanse" [22]. At the time of our interviews, the participants had already experienced a significant amount of "Zoom fatigue" [23], both in family communication and work. One participant talked about her lack of being around others as follows:

"I feel like I want to be in places where people are around, more than ever. I actually rented a communal workspace with strangers. Um, because I just couldn't be at home anymore by myself. It was, it was too much. It was too hard. Because I used to go out to (work) quite a bit to do studying and work and all that kind of stuff, where there were tons of people all the time, and you can see them. However, then when we switched over to being at home, and I had no longer had access to that. And all my work went online, right? So, all the communications are now online. [. . .] I've been renting the space now for I think I started, like in July, like so it's been almost a year. Because I just couldn't be at home anymore. Like, I just couldn't be by myself." (P15, age 25–34)

P15, like many others, reports feelings of isolation and the desire to leave home following the switch to online work. Her need to rent a communal workspace to be among strangers came from her desire to leave her home, where she felt alone and lonely.

Yet, another participant, P7, who lives with her husband and three children, described her desire to leave her house to separate the company she keeps at home from the company she keeps in her individual personal life (church):

"I miss going to church in person . . . I've never liked watching it online. That's another I guess, technological assistance to me. Um, so I missed it. I missed the space of church and I miss it . . . but I liked the physical space of work, I like leaving my house, I like leaving my children, I like them having their space and having my spaces going. I'll miss those things for sure." (P7, age 35–44)

For P7, a home is a place immersed in human contact. At the same time, the home became a place where three places (work, church, and home) overlapped too much, leading to a desire for personal space she once found at work or church. The need to be outside of the home or in the co-presence of others unmediated by technology is felt whether one is alone at home or constantly surrounded by family members. In these situations, touching another person or using simulated touch technology from home may not meet their emotional needs.

As workarounds, participants described non-digital social arrangements where they would meet up with others outdoors in an open space without physically coming close to or touching one another.

“We [a dear friend and I] would park our cars far away, put the windows down, and drink coffee. I had another friend, we’re, on the first of every month we started, we would like drive to the ocean, and park two spots away from each other, just roll our windows down and have breakfast together at the beach [. . .] and it’s like you know being near that person at the ocean when the sun’s coming up and we’re drinking some coffee.”
(P8, age 35–44)

This example demonstrates the importance of physical co-locatedness without technological mediation on multiple levels. First, people’s desire to move away from technology to feel the physical presence of others in the fore, such as a shared sense of presence, is important because being physically together facilitates mutual focus, shared emotion, and rhythmic entrainment [21,37]. Second, people seek ways to minimize risk and maximize the feeling of being with each other. Physical co-locatedness without touch is one way people reported balancing safety and human-to-human connectedness.

Reflection on HCI Touch Technologies

Our findings showed that participants wanted physical co-locatedness even without touch. This type of interaction pattern grew as concerns about COVID-19 continued. These findings align with existing research that has explored ways of supporting mediated social presence over distance through technologies [38] and social touch in human–computer interaction [6]. However, as participants described, videoconferencing technologies were insufficient for mediating social presence. There was a desire to share physical spaces with strangers and acquaintances without touch as a requirement.

HCI’s touch technology trend, thus far, focuses on recreating the sensation of touch itself, so much so that there appears to be **an over-reliance on recreating touch as a mediator of connection above the context in which touch happens**. This is because touch technologies have been primarily designed and evaluated in controlled lab settings due to technology limitations. Our study highlights that participants cherished experiences of shared physical connection with other people even when closeness and touch were not possible, e.g., listening to the same ocean waves, drinking coffee from the same place, sharing the same ambiance, being physically together with “mutual focus, shared emotion, and rhythmic entrainment” [21,37]. Touch technologies should consider shifting from focusing solely on touch to paying attention to other sensory elements in physical colocation. We must not neglect other senses of the body, such as hearing the breeze, sitting on the same grass, etc. In line with research on co-presence as a multifaceted and dynamically negotiated experience [21,39], these findings suggest ambient co-presence (e.g., working alone in a café full of people) as a way people have connected pre-COVID-19, and is a tool used during COVID-19 to “feel” connected through physical co-locatedness, even with strangers.

4.3. Technology Amplifying the Feeling of Missing Human-to-Human Touch

The third theme relates to how current technological solutions amplify the feeling of missing human-to-human touch. As the pandemic continued to run its course in 2021 (and beyond), people turned to alternative means, such as Zoom video celebrations and happy hours instead of in-person get-togethers. These solutions, however, were short-lived. As

mentioned in the previous section, key reasons for the limited usefulness of such solutions were “Zoom fatigue” [23] and struggling with “feeling close to remote family and friends using technology” [22]. These reflect findings similar to our study, but here we focus on the struggle to feel close without any potential to reach out and touch a friend or loved one. Beyond the infrastructural and logistical challenges of unstable internet access and finding times to meet, in the long-term, the use of technology, particularly video chats, served as a reminder to respondents that they were not sharing proximal space (within arm’s reach) with loved ones. For example, one participant described their inability to communicate care and emotions without touch through video chat.

“That’s another reason why I don’t like doing like the Zoom happy hours or friend meetups because I’m very—not only do I use my hands a lot to speak but I also am touchy-feely like my hugging I like to hug my friends and, like I just feel more connected to someone when I’m like touching their arm when I’m speaking to them or I feel like it’s easier for me to empathize with someone when I’m able to like pat them on their back or put my hand on their shoulder and it’s . . . I’m not the best with words, so I feel like it’s easier for me to convey what I’m feeling through touch.” (P9, age 35–44)

After trying out different video chat activities, this participant, like many others, felt an awareness of its constraints. Zoom, a primarily verbal and visual platform, does not allow for communicating non-verbal conversational cues of care, such as touching a friend’s arm or hugging. This inability to reach out and touch loved ones was so acutely felt that the participant shied away from activities where one could not be within arm’s reach, such as remote happy hours or even physically distanced friend meetups.

Relatedly, experiences with video chats also reminded participants of their inability to read or express bodily cues that one could readily sense when they are within arm’s reach of their loved ones. Another participant expressed her disdain for video chat, mainly her frustration with an inability to gauge eye contact.

“Like even, like smaller interactions that aren’t really like touched, but they’re like ways that you get closer with people. Like eye contact, how does that work like on zoom? It kind of sucks on all video ad nauseum specifically, but like all video conferencing platforms that kind of sucks . . . I tend toward like phone calls, because it’s just like, less of the reminder that we’re not in the same place.” (P4, age 25–34)

Although video chats can display faces, subtle cues are more challenging to gauge over video chat than face-to-face physical interactions. Depending on the activity, mainly gathering with loved ones, this inability to engage in eye contact can serve as a reminder of the distance between them and, in turn, may prompt people to forgo video chats. In this case, they shifted to single modality devices such as telephones. If the Zoom video enhanced visual absence (instead of doing the opposite of what it was designed for), will remote touch technology foreground the lack of touch? One has to ask, if technology use does work in this vein, how might tactile technologies fare in mainstream adoption?

When engaging in select synchronous activities, such as small dinner parties and game nights with friends and family, participants reported becoming more aware of how they could not participate in person. For example, a respondent reported on their experience with a Zoom family dinner:

“That sense of frustration was the highest when, because they didn’t know where to place me so that I could still hear them and while they were eating, they just put me in front of the wall. I was like, ‘No!’ I want to jump out of the screen. [...] Yeah it felt awkward that they were eating and then I was not eating, having a snack. And then my mother was telling my father, ‘Could you pass me this? Could you pass me that?’ And then, it was like okay, that banal situation. It made me aware that I was not there, I was just. It made me realize that, even if we had like this video there was some sort of distance just because they could not do the same kind of banal stuff. Like, I could not pass the salt to my mom.” (P18, age 25–34)

Here, the inability to be within arm's reach of his parents at the table yet watching them eat over Zoom further reinforced the presence and limitations of technology, and additionally served as a reminder that the respondent could not participate in even mundane activities with his loved ones.

Beyond the more disappointing pragmatic aspects mentioned previously, the idea of a digitally mediated touch experience was not appreciated by respondents, perhaps influenced by prior experiences with video chat and other forms of communication. For example, respondents mentioned that there “were no technologies that could replace touch” and “nothing would be quite the same as physical interaction”. When asked about ways current technology has helped in any limitations with touch due to COVID-19, one respondent summed up many interviewees' sentiments:

“Technology helping it? I don't know that technology helps it. Technology to me is electronic. And I don't know of any ways that that would make your ability to touch better. It will just keep it worse where you can't. [...] Well, to me on talking to you on Zoom to me that's technology that's how we communicate, or phone or text. You can't judge somebody electronically, that I know of. It [touch] just affirms the fact that you are communicating because when you put your hand on somebody. It says, I'm directly interfacing with you, I'm listening, I know who you are. To me that is just an innate response to interaction.” (P6, age 80–90)

For P6, using digitally mediated communication technologies made the lack of human-to-human contact more pronounced. There is a strong sense among many of our respondents that their experience will not be as fulfilling as face-to-face touch with loved ones. Again, we point this out to highlight resistance to touch-simulating devices if they are to be available more widely. This sentiment is not unfounded, as previous experience with digitally mediated communication has informed this expectation about physical connection and technology. As one respondent described:

“I think technology has definitely failed to support any type of physical touch. I think the technology has met my emotional needs and definitely gone way past any social feeds. However, as far as a physical feeling with people. If it's text, email, or Zoom, that, I have no visceral reaction at all.” (P13, age 44–55)

Here, the participant separates the emotional needs fulfilled by social media, and physical responses, which remain unfulfilled by current technologies. Although many of our participants wanted to engage in touch activities with their family and found that technology did not satisfy that need, some felt that their desire to touch was so strong that they would rather not use video calls or technologies because it made them more aware of touch deprivation. We acknowledge that the participants are sharing these feelings without having experienced any state-of-the-art touch technologies, as they have all been in development in labs. However, we highlight this as an important opportunity for HCI researchers to understand people's feelings, contexts, and attitudes towards touch, people's practices with existing technologies, and to further explore the future design of technology that attempts to mediate touch in pandemic times.

Furthermore, underneath the stories the participants shared, there were often deeply heartfelt and challenging circumstances. The following participant describes the very last moment she physically had with her partner:

“Obviously, my boyfriend and the ability to even be with him because he was in a rest home and they were under a very severe lockdown situation. It meant no more him coming on the weekends, being able to be with him. Finally, just the week before he actually died, I was able to get in, and they weren't looking and we had one quick hug before I had to leave. It was. I just selfishly, I just remember when the whole thing hit. I don't have that many years left—we didn't. And there goes one of the last few chances to go on a trip or do anything together.” (P6, age 80–90)

This heartbreaking account that describes how physical distancing measures devastate the shared sensory experience between loved ones during the pandemic at a time when we needed touch the most. During the social distancing restrictions, people became acutely aware of touch as a channel to convey immediate socio-emotional meanings and to reinforce social bonds [7]. At the same time, participants used technology to fill the void of touch and the void of being within arm's reach of a loved one. Human-to-human touch was described as a "visceral reaction" (P13), "innate response" (P6), and "human reaction" (P8). Conversely, the participants described technology-mediated connection as "I wanted to jump out of the screen" (P18) and "technology to me is electronic" (P6). Through trial and error, people discovered the limitations of what current technology could deliver to mediate connection. Through this experience, many have realized that using technology to connect may amplify feelings of physical isolation.

Reflection on HCI Touch Technologies

Many HCI touch technologies have been developed under the pre-pandemic assumption that when touch is not possible, people may agree to invest in using technology to stand in for the missed touch. Given our participants' experiences of how touch matters in their post-pandemic lives, we challenge this utopian assumption. Instead, physical distancing measures during the pandemic amplified people's visceral urge to use their bodies to reach out to another body, to show their physical presence, and to show their genuine support for another human being. Thus, people are resisting the idea of technology mediating their very touch.

Furthermore, HCI touch technology research has, thus far, focused on whether simulated touch could convey isolated emotions, such as basic emotions (i.e., anger, fear, sadness, disgust, and enjoyment) between pre-arranged pairs over distance. Our participants described **various emotions and feelings beyond the basic five categories researched by HCI touch technologies**, e.g., [14,15]. P6's story is particularly pertinent, describing the last hug she gave to her partner before he passed away in his nursing home. No technology could likely have replaced their last touch. In fact, in this situation, touch might be the last thing people would be willing to replace with technology. We conjecture that touch simulation will unlikely act as a satisfactory stand-in for real touch in a pandemic era.

4.4. New Appreciation of Human-Connectedness

The fourth theme from our analysis was related to a newfound appreciation of human connection. Prior work in HCI has focused on interactions that broker feelings of relatedness, "the feeling when you have regular intimate contact with people who care about you, rather than feeling lonely and uncared for" [10]. Prior studies have shown that among all psychological needs, relatedness was fulfilled most intensely through social media content and technology [40]. Although physical touch is one of the primary means to broker relatedness, it remains to be seen if technologies that simulate physical touch can elicit a similar response. Interactions are increasingly mediated through digital technologies outside the lab, work, and personal life, making social interactions less tactile [6]. COVID-19 has no doubt accelerated this trend. There is an open question: What experiences have people found positive regarding touch interactions with loved ones in this physically distanced and touch-restricted time? We found that people are not longing for solutions to stand in for missing touch, but instead finding a deeper appreciation of human connection through non-digital forms of contact.

Several respondents mentioned that they sent physical gifts through the mail to maintain connection. When asked about sharing, several respondents said they would be mailing objects to friends and family, such as albums, sketchbooks, postcards, books, flowers, and entertainment media. For entertainment (albums, books, and movies), respondents mentioned that either it was something they liked and thought their friend would like or something their friend explicitly liked and was bought as a present. To many, the act of sharing communicates "I am thinking of you" (P5), "I care" (P11), and "We exist" (P4),

often referencing a shared memory or an ongoing inside joke (P15). So, it is indeed the thought that counts in gift giving, and this thought often represents some reminder of the connection between giver and recipient.

Participants reported appreciating the novelty and effort of sharing a physical gift, because making and sending a gift prompted an appreciation for human connection. For example, one participant described sending a journal back and forth to correspond with a friend across the country:

"I could easily send a note, virtually, or call someone versus, like, mailing them something that's like ten bucks. I think there's something about gifts in general. There's something about, like, the time and effort, whether it be like monetary effort or time. So I guess it's about the effort that it took, showing you care. And then there's something about it being different than what's normally happening." (P5, age 25–34)

To this participant, like others, sending mail indicates extra time and effort put forth in giving something to loved ones, even if it is just a small gift or message. Conversely, digitally mediated messaging is less of a novelty because it is quicker, cheaper, and low effort.

While some participants described disinfecting physical objects such as groceries and mail, especially in 2020, several participants mentioned their increased appreciation of "shared tactility" when receiving physical mail. As one participant described when receiving mail from loved ones:

"I think that it's [mail] something that is so tactile and the thing that so clearly reflects another person, and you know they were holding it. Like I feel like, it really made me appreciate some of those analog things a lot more, because I wasn't able to do things like give a person a hug or share a meal with them. I think anything that felt very personal in that way felt really valuable." (P8, age 35–44)

Another participant described her experience of sending and receiving postcards through her postcard group:

"Over Zoom I have a writing group, and then I have a postcard group and sending that postcard every week, so go through the list, sending that postcard to someone, even though I've seen them on zoom it's like. It's like my DNA, like a piece of me is getting put in their hands. That we're touching each other. Which you know, I've been in this postcard group before, about two years ago and I didn't feel that way, I was like okay cool I get a postcard, that back and forth. However, when I get a postcard from someone in the group I mean I keep it on my little desk for a couple days, submit a little pile that I won't throw away it's just like that's come from their hands, and that means a lot more to me right now, then it did two years ago." (P13, age 44–55)

Here, physical mail brokered a sense of shared tactility that prompted an appreciation of "analog" pre-pandemic activities of connection that were restricted at the height of the pandemic, such as hugs and sharing food.

Participants reported using alternative greetings such as fist bumps or elbow bumps when people felt safe enough to touch their friends and family. These modifications to greetings were described as "short-lived" (P4), "awkward" (P18), "fake" (P13), and "unnatural" (P14). However, when participants felt safe hugging loved ones, many noticed a deeper appreciation of hugging. As one participant described:

"There is like one friend that I've hugged a couple times over the last year. Like a friend that lives close to me and that we have been, like, very safe in our actions, so we felt comfortable hugging a couple times over the last year and that definitely turns what would feel like sort of like an everyday occurrence into something that feels kind of like special. Like oh my gosh, I actually hugged somebody today. That's like a really big deal." (P14, age 35–44)

Although modifications to one's normal touch activities (i.e., elbow bumps to greet loved ones) provided a less optimal experience, experiencing touch (i.e., a hug) may elicit

a heightened appreciation of human connection in physically restricted times such as the pandemic.

Reflection on HCI Touch Technologies

The touch deprivation that people may have felt during the COVID-19 pandemic is unprecedented. Before the pandemic, **HCI touch technology research assumed that any lack of touch that may have occurred between people was likely temporary** (e.g., to support an intimate couple while one is on a business trip). Perhaps that is why we see touch has been commodified in these technologies. Concerns towards touch that come from the tension between safety and face-to-face interaction are likely to change so long as new variants pose a health concern (e.g., recent omicron variant and subsequent sub-variant surges). This evaluation dynamically changes like the ebb and flow of infection and vaccination rates, as well as people's changing attitude towards human-to-human co-presence and touch. We may need to approach touch technology with the assumption that we are not returning to "normal". Instead, studies in HCI involving touch and co-location should consider the prolonged uncertainty of COVID-19 when physically engaging with others or the ever-present concern of COVID-19 safety.

This finding shows that participants are much more reflective of the significance of touch because of the deprivation experienced during the strict social distancing measures enforced in the beginning of the pandemic in the United States. Touch felt momentous when people could successfully experience it after prolonged physical isolation. People developed an increased appreciation for touch, as well as feelings associated with it. Some participants expressed that it was "worth the wait". Our study shows that touch deprivation does not always mean we must devise technological solutions to mediate the missed touch. On the contrary: given the highly acute appreciation people have developed for touch during the pandemic, it is even more difficult for technology to take the place of meaningful touch.

5. Discussion

This study is a timely investigation on the sense of touch, which significantly decreased during the COVID-19 pandemic. Human-to-human touch, sharing physical objects, and co-location are at the core of these shifting experiences due to the physical distancing measures and self-distancing strategies that address different concerns and trade-offs. Our overarching goal in this research was to investigate how social distancing measures during the COVID-19 pandemic shifted how people connected with loved ones, with particular attention to touch and touch-adjacent activities. We found that new practices and preferences emerged as people adapted touch and touch-adjacent interactions, i.e., being co-located but at a safe distance, sharing and mailing physical objects. Furthermore, participants used various types of information (social media, word of mouth, past personal history) to evaluate whether to engage with others in an enclosed space or use socially distanced means to gather.

In the wake of social distancing measures, a wave of ongoing explorations in diverse areas, including HCI, have reported significant shifts in how people interact due to COVID-19 [20–22]. Our participants, like many, shifted face-to-face group activities to remote ones using digital technology and expressed their dissatisfaction with remote gatherings. Over a year-long period, participants reported preferring in-person gatherings over remote ones, feeling an amplified sense of isolation during digitally mediated remote gatherings, and having a newfound appreciation for co-location and physical sharing when it felt safe to engage in such activities. Together, these findings show that in a time when tools are abundant to connect via audio and visual means, there remains a palpable yet subtle sense of disconnection using such tools.

From the stories our participants shared with us, we observed four main themes regarding attitude and activity changes in relation to touch, co-location, and sharing during the pandemic: first, new efforts to evaluate safety; second, physical co-location without

touch as an alternative connection; third, technology solutions amplify the sense of isolation; and fourth, a newfound appreciation for human connectedness. Accordingly, we believe it is essential to position the role of technology by grounding future designs in understanding these changing experiences, needs, and expectations during the pandemic.

First, most HCI touch technologies have been designed for paired interactions between romantic partners (e.g., [1–3,13–17]). Yet, our study shows that our participants wished to reach out and touch family members, friends, colleagues, and even strangers. In contrast, HCI has yet to expand beyond presumed behaviors between pre-determined partners, such as spontaneity and unpredictability of touch encounters in everyday life, and dynamically changing desires to touch or not touch others due to unprecedented safety concerns. Furthermore, the pre-pandemic assumption that fixed pairs of people need to be committed and agree on using technology to stand in for missed touch should be reconsidered.

Second, HCI has focused on creating and conveying distinctive emotions (e.g., enjoyment, anger, fear, sadness, etc.) through simulated touch, focusing on a specified and isolated location (e.g., palm, part of an arm, cheek, etc.) between a pair of romantic partners in controlled lab settings. However, our participants' stories illustrate that touch was felt through different parts of their bodies in a variety of manners (e.g., pat on their back, hand on one's shoulder, leaning one's body against another's body, arm in arm, etc.) to convey subtle yet deeply meaningful encompassing feelings towards others as they experienced "deep griefs", "deep emotions", and "life-changing events" during the pandemic. Touch is not just about communicating a distinct feeling through an actuation. Touch is a powerful form of contact between people that takes many forms in daily life, from expressing emotions to showing genuine care. We need to become more aware of how HCI research, in an attempt to commodify touch, simplifies touch to the degree that removes the nuanced understanding. By being clear, we can start to address some of the issues we raised.

Third, HCI's trend in touch technology seems to focus on recreating the sensation of touch as a form of social connection, which fails to recognize that touch is not a requirement for social connection. Our study shows that people appreciate physically connecting in co-located spaces, even without touching. For example, they participated in such activities as enjoying the same atmosphere, ambient noises, smells, or sharing drinks and food while maintaining physical distance. The new direction for touch technology may be to shift the focus away from touch itself, and to pay more attention to other modalities in the shared physical context to holistically increase the immersion of mediated communication.

Finally, HCI touch technology research assumed that the lack of touch between people was temporary (e.g., to support an intimate couple while one is on a business trip). This pandemic has shown us that as long as new virus variants pose a health concern (e.g., the recent Omicron variant and subsequent sub-variant surges), our hesitation towards touch and lack thereof will continue to change dynamically. In particular, this study paints a picture of the "new normal" of the ever-present trade-off between safety and isolation. Furthermore, our study shows that, given the profound appreciation people have developed for genuine human-to-human touch, it is more likely that people will choose to wait for the moment to engage in real touch rather than seeking technological simulations.

Because of the COVID-19 pandemic, we should reconsider these assumptions for the design of touch technologies. Our findings suggest that we must re-envision the relationship between touch and technology when designing communication and interaction technologies, and consider a broader spectrum of interactions by considering the end goal of touch—human connection. For example, this may require interaction designers to think about how to quickly change between relationship types or paired interactions between multiple family members. It may also involve design explorations into the role of technology for enhancing and not simulating touch, as well as broader bodily experiences [41–43]. It may include remaking new touch interactions from the ground up with sociotechnical imaginaries [28,29]. The recent pandemic has shown that designing technologies to enhance the human experience will require more than technological innovation or mediated experiences. Instead, designers must envision the whole person, context, and societal conditions.

6. Conclusions

Results from our interview study suggest that when faced with the challenge of minimizing risk while maximizing ways to feel connected, people looked for new spaces where they could physically co-locate without touch, unrelated to communication technologies. The need to decrease the use of communication technologies came from a desire to be less reminded of the feelings that resulted from technology and to attend to the physical and social entrainments that come from the presence of their loved ones. Further, when people successfully engaged in physical touch, such as a hug among trusted friends, the touch felt momentous, and people found a new appreciation for social touch they did not feel before. Based on these results, we suggest several new considerations for touch technology design for a future post-COVID-19 pandemic world. Rather than focusing on touch based on our pre-COVID-19 assumptions, touch technology designers and researchers must consider interfaces attentive to the holistic experience of touch, individual safety concerns, need for human touch, and independence from technology-mediated experiences increasingly omnipresent in our daily lives.

7. Limitations

Our study is limited, as the participants were all from the USA, so it may not reflect cultures outside the United States. Interviews were conducted a year after the onset of COVID-19 physical distancing restrictions. Therefore, accounts of some activities and perceptions of lived experiences dealing with the pandemic may be under- or over-reported. These factors could affect how people engage with loved ones over time, and their overall feelings about touch, since cultural practices may influence comfort and frequency of touch in everyday life. Additionally, we interviewed participants in the age range of 20 to 80+ who were educated and reported regular social contact with people outside their household. Future studies could focus on recruiting participants with an increased need for physical interaction, such as the elderly, who often experience increased isolation, less frequent touch [34], and are less experienced with communication technology than younger groups [26]. Our study is also limited in that participants reported their activities and feelings about touch and touch-adjacent activities mediated by mostly screen-based activities. This potentially led to biased reporting about their feelings towards touch, since there is no touch provocation in the protocol. Future studies could utilize touch-based probes to help participants imagine touch-based technologies with recent experience with simulated touch and touch-adjacent activities to fully capture the possibilities of touch technologies.

Author Contributions: Conceptualization, K.R., N.M.B., S.J., P.B. and K.D.; methodology, K.R., N.M.B. and S.J.; validation, K.R., N.M.B. and S.J.; formal analysis, K.R., N.M.B. and S.J.; investigation, K.R., N.M.B. and S.J.; resources, K.R., N.M.B., S.J., P.B. and K.D.; data curation, K.R., N.M.B. and S.J.; writing—original draft preparation, K.R., N.M.B. and S.J.; writing—review and editing, K.R., N.M.B., S.J., P.B. and K.D.; visualization, K.R., N.M.B. and S.J.; supervision, K.R., P.B. and K.D.; project administration, K.R., P.B. and K.D.; funding acquisition, K.R., P.B. and K.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Google.

Institutional Review Board Statement: The study was conducted in accordance with and approved by the Institutional Review Board of University of California, Berkeley (Protocol ID: 2020-12-13902, 13 January 2021).

Informed Consent Statement: Informed consent was obtained from all participants involved in the study.

Data Availability Statement: Not applicable.

Acknowledgments: We would like to thank all the participants who took part in the study, and the reviewers for their feedback.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Brave, S.; Dahley, A. InTouch: A medium for haptic interpersonal communication. In Proceedings of the CHI '97 Extended Abstracts on Human Factors in Computing Systems (CHI EA '97), Atlanta, GA, USA, 22–27 March 1997; Association for Computing Machinery: New York, NY, USA, 1997; pp. 363–364. [\[CrossRef\]](#)
2. Mueller, F.F.; Vetere, F.; Gibbs, M.R.; Kjeldskov, J.; Pedell, S.; Howard, S. Hug over a distance. In Proceedings of the CHI '05 Extended Abstracts on Human Factors in Computing Systems (CHI EA '05), Portland, OR, USA, 2–7 April 2005; Association for Computing Machinery: New York, NY, USA, 2005; pp. 1673–1676. [\[CrossRef\]](#)
3. Zhang, Z.; Alvina, J.; Héron, R.; Safin, S.; Détienné, F.; Lecolinet, E. Touch without Touching: Overcoming Social Distancing in Semi-Intimate Relationships with SansTouch. In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21), Yokohama, Japan, 8–13 May 2021; Association for Computing Machinery: New York, NY, USA, 2021; pp. 1–13. [\[CrossRef\]](#)
4. Erk, S.M.; Toet, A.; Van Erp, J.B. Effects of mediated social touch on affective experiences and trust. *PeerJ* **2015**, *3*, e1297. [\[CrossRef\]](#)
5. Morrison, I.; Löken, L.; Olsson, H. The skin as a social organ. *Exp. Brain Res.* **2009**, *204*, 305–314. [\[CrossRef\]](#) [\[PubMed\]](#)
6. Van Erp, J.B.F.; Toet, A. Social touch in human–computer interaction. *Front. Digit. Humanit.* **2015**, *2*. [\[CrossRef\]](#)
7. Von Mohr, M.; Kirsch, L.P.; Fotopoulou, A. Social touch deprivation during COVID-19: Effects on psychological wellbeing and craving interpersonal touch. *R. Soc. Open Sci.* **2021**, *8*, 210287. [\[CrossRef\]](#)
8. Rogers, Y. Interaction design gone wild. *Interactions* **2011**, *18*, 58–62. [\[CrossRef\]](#)
9. Dourish, P. *Where the Action Is: The Foundations of Embodied Interaction*; MIT Press: London, UK, 2004.
10. Hassenzahl, M.; Heidecker, S.; Eckoldt, K.; Diefenbach, S.; Hillmann, U. All You Need is Love. *ACM Trans. Comput. Interact.* **2012**, *19*, 1–19. [\[CrossRef\]](#)
11. Ryan, R.M.; Deci, E.L. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Amer. Psychol.* **2000**, *55*, 68–78. [\[CrossRef\]](#)
12. Gemperle, F.; DiSalvo, C.; Forlizzi, J.; Yonkers, W. The Hug: A new form for communication. In Proceedings of the 2003 Conference on Designing for User Experiences (DUX '03), San Francisco, CA, USA, 6–7 June 2003; Association for Computing Machinery: New York, NY, USA, 2003; pp. 1–4. [\[CrossRef\]](#)
13. Buchenau, M.; Suri, J.F. Experience prototyping. In Proceedings of the 3rd Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques (DIS '00), New York, NY, USA, 17–19 August 2000; Association for Computing Machinery: New York, NY, USA, 2000; pp. 424–433. [\[CrossRef\]](#)
14. Freriks, A.D.; Heylen, D.; Huisman, G. TaSST: Affective mediated touch. In Proceedings of the 15th ACM on International Conference on Multimodal Interaction (ICMI '13), Sydney, Australia, 9–13 December 2013; Association for Computing Machinery: New York, NY, USA, 2013; pp. 315–316. [\[CrossRef\]](#)
15. Obrist, M.; Subramanian, S.; Gatti, E.; Long, B.; Carter, T. Emotions Mediated Through Mid-Air Haptics. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15), Seoul, Korea, 18–23 April 2015; Association for Computing Machinery: New York, NY, USA, 2015; pp. 2053–2062. [\[CrossRef\]](#)
16. Park, Y.-W.; Park, J.; Nam, T.-J. The Trial of Bendi in a Coffeehouse: Use of a Shape-Changing Device for a Tactile-Visual Phone Conversation. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15), Seoul, Korea, 18–23 April 2015; Association for Computing Machinery: New York, NY, USA, 2015; pp. 2181–2190. [\[CrossRef\]](#)
17. Park, Y.-W.; Hwang, S.; Nam, T.-J. Poke: Emotional touch delivery through an inflatable surface over interpersonal mobile communications. In Proceedings of the 24th Annual ACM Symposium Adjunct on User Interface Software and Technology (UIST '11 Adjunct), Santa Barbara, CA, USA, 16–19 October 2011; Association for Computing Machinery: New York, NY, USA, 2011; pp. 61–62. [\[CrossRef\]](#)
18. Leithinger, D.; Follmer, S.; Olwal, A.; Ishii, H. Physical telepresence: Shape capture and display for embodied, computer-mediated remote collaboration. In Proceedings of the 27th Annual ACM Symposium on User Interface Software and Technology (UIST '14), Honolulu, HI, USA, 5–8 October 2014; Association for Computing Machinery: New York, NY, USA, 2014; pp. 461–470. [\[CrossRef\]](#)
19. Nakagaki, K.; Fitzgerald, D.; Ma, Z.; Vink, L.; Levine, D.; Ishii, H. InFORCE: Bi-directional 'Force' Shape Display for Haptic Interaction. In Proceedings of the Thirteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '19), Tempe, AZ, USA, 17–20 March 2019; Association for Computing Machinery: New York, NY, USA, 2019; pp. 615–623. [\[CrossRef\]](#)
20. Banerjee, D.; Rao, T.S.S.; Kallivayalil, R.A.; Javed, A. Psychosocial Framework of Resilience: Navigating Needs and Adversities During the Pandemic, A Qualitative Exploration in the Indian Frontline Physicians. *Front. Psychol.* **2021**, *12*, 622132. [\[CrossRef\]](#)
21. Collins, R. Social distancing as a critical test of the micro-sociology of solidarity. *Am. J. Cult. Sociol.* **2020**, *8*, 477–497. [\[CrossRef\]](#)
22. Heshmat, Y.; Neustaedter, C. Family and Friend Communication over Distance in Canada During the COVID-19 Pandemic. In Proceedings of the Designing Interactive Systems Conference 2021, Virtual Event, 28 June–2 July 2021; Association for Computing Machinery: New York, NY, USA, 2021; pp. 1–14. [\[CrossRef\]](#)
23. Bailenson, J.N. Nonverbal overload: A theoretical argument for the causes of Zoom fatigue. *Technol. Mind Behav.* **2021**, *2*. [\[CrossRef\]](#)
24. Syvertsen, T.; Enli, G. Digital detox: Media resistance and the promise of authenticity. *Converg. Int. J. Res. Into New Media Technol.* **2019**, *26*, 1269–1283. [\[CrossRef\]](#)
25. Fuchsberger, V.; Dziabiola, M.; Mešić, A.; Nørskov, D.; Vetter, R. HCI taking turns. *Interactions* **2021**, *28*, 38–43. [\[CrossRef\]](#)

26. Pew Research Center. The Internet and the Pandemic. Available online: <https://www.pewresearch.org> (accessed on 1 September 2021).
27. Field, T. *Touch Cambridge, Massachusetts*; The MIT Press: London, UK, 2014. [[CrossRef](#)]
28. Jewitt, C.; Barker, N.; Golmohammadi, L. Creative Probes, Proxy Feelers, and Speculations on Interactive Skin. *Multimodal Technol. Interact.* **2022**, *6*, 22. [[CrossRef](#)]
29. Jewitt, C.; Price, S.; Steimle, J.; Huisman, G.; Golmohammadi, L.; Pourjafarian, N.; Frier, W.; Howard, T.; Askari, S.I.; Ornati, M.; et al. Manifesto for Digital Social Touch in Crisis. *Front. Comput. Sci.* **2021**, *3*. [[CrossRef](#)]
30. Miles, M.B.; Huberman, A.M. *Qualitative Data Analysis: An Expanded Sourcebook*, 2nd ed.; Sage: Thousand Oaks, CA, USA, 1994.
31. Bhattacharjee, A. *Social Science Research: Principles, Methods, and Practices*; Global Text Project: Athens, GA, USA, 2012.
32. Gephart, R. Paradigms and research methods. *Res. Methods Forum.* **2012**, *4*, 1–8.
33. Braun, V.; Clarke, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* **2006**, *3*, 77–101. [[CrossRef](#)]
34. Field, T. Touch for socioemotional and physical well-being: A review. *Dev. Rev.* **2010**, *30*, 367–383. [[CrossRef](#)]
35. Devendorf, L.; Lo, J.; Howell, N.; Lee, J.L.; Gong, N.-W.; Karagozler, M.E.; Fukuhara, S.; Poupyrev, I.; Paulos, E.; Ryokai, K. “I don’t Want to Wear a Screen”: Probing Perceptions of and Possibilities for Dynamic Displays on Clothing. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI ’16), San Jose, CA, USA, 7–12 May 2016; Association for Computing Machinery: New York, NY, USA, 2016; pp. 6028–6039.
36. Sengers, P.; Gaver, W.W. Staying open to interpretation: Engaging multiple meanings in design and evaluation. In Proceedings of the 6th conference on Designing Interactive systems (DIS ’06), University Park, PA, USA, 26–28 June 2006; Association for Computing Machinery: New York, NY, USA, 2006; pp. 99–108. [[CrossRef](#)]
37. Goffman, E. *Interaction Ritual*; Doubleday: New York, NY, USA, 1967.
38. Oh, C.S.; Bailenson, J.N.; Welch, G.F. A Systematic Review of Social Presence: Definition, Antecedents, and Implications. *Front. Robot. AI* **2018**, *5*, 114. [[CrossRef](#)]
39. Madianou, M. Ambient co-presence: Transnational family practices in polymedia environments. *Glob. Netw.* **2016**, *16*, 183–201. [[CrossRef](#)]
40. Hassenzahl, M.; Wiklund-Engblom, A.; Bengs, A.; Hägglund, S.; Diefenbach, S. Experience-Oriented and Product-Oriented Evaluation: Psychological Need Fulfillment, Positive Affect, and Product Perception. *Int. J. Hum. Comp. Interact.* **2015**, *31*, 530–544. [[CrossRef](#)]
41. Elvitigala, D.S.; Boldu, R.; Nanayakkara, S.; Matthies, D.J.C. TickleFoot: Design, Development and Evaluation of a Novel Foot-Tickling Mechanism That Can Evoke Laughter. *ACM Trans. Comput. Interact.* **2022**, *29*, 1–23. [[CrossRef](#)]
42. Karpashevich, P.; Sanches, P.; Garrett, R.; Luft, Y.; Cotton, K.; Tsaknaki, V.; Höök, K. Touching Our Breathing through Shape-Change: Monster, Organic Other, or Twisted Mirror. *ACM Trans. Comput. Interact.* **2022**, *29*, 1–40. [[CrossRef](#)]
43. Price, S.; Bianchi-Berthouze, N.; Jewitt, C.; Yiannoutsou, N.; Fotopoulou, K.; Dajic, S.; Virdee, J.; Zhao, Y.; Atkinson, D.; Brudy, F. The making of meaning through dyadic haptic affective touch. *ACM Trans. Comput. Interact.* **2022**, *29*, 1–42. [[CrossRef](#)]