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From Silence to Dialogue: Boosting Collocated Social Interactions with Technology

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Figure 1: The Boost interactive audio narrative box in use during a social interaction. Two individuals are engaging with their smartphones while Boost is positioned on the table between them.

ABSTRACT

Social interactions play a crucial role in promoting personal development, mental health, and overall well-being. Despite the importance of collocated social interactions, HCI research has focused on initiating encounters rather than sustaining meaningful relationships. To address this gap, we designed Boost, a conversational aid tool that monitors the quality of social interactions between users and introduces movie-trivia based on their interests aimed at enriching their social interactions. We evaluated Boost through a study with 38 participants, findings reveal that it has potential to minimize silent moments, reduce negative feelings, enhance engagement, and improved interaction quality. Our results highlight the importance of designing future HCI tools that are context-aware, respect privacy, and enhance social interactions by supporting, not controlling, human interaction dynamics. We advocate for a balanced approach that acknowledges the complexity of social interactions, recognizing the value of silence and user autonomy.

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CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in collaborative and social computing**; Natural language interfaces; • **Computing methodologies** → *Natural language generation.*

KEYWORDS

Collocated Social Interactions, Design for Behavior Change, User Study

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1 INTRODUCTION

The importance of social interactions in promoting personal development, mental health, and overall well-being is widely recognized in the literature [34, 36, 43]. Intrinsic psychological needs, such as the desire for relatedness and connection to others, underlie our social interactions, as supported by prevailing theories in psychology [11]. Research has shown that both the quality and quantity of social connections and interactions significantly affect individual health outcomes [29, 39] and are essential to well-being [21, 25].

Over the past decade, Human-Computer Interaction (HCI) studies have explored ways to enrich collocated social interactions—"a term that refers to all kinds of purposeful interpersonal communication that takes place in close physical proximity between two or more persons [30]"—through technological interventions. These interventions aim to facilitate ongoing social situations, improve means of social interaction, and foster a sense of community, thereby promoting more meaningful and engaging in-person encounters. Examples include interactive storytelling platforms like PicoTales that encourage co-creation and shared experiences [33], visual feedback tools like Conversation Clock that promote balanced verbal contributions [5], icebreaker technologies like FishPong [47] and CueSense [18] that support social interaction among strangers or new encounters, and devices like BubbleBadge [12], Social Devices [19], and Whisper [14] that provide supplementary conversational cues or suggest topics to enrich interactions by revealing common ground. Understanding the impact of these technologies on collocated interactions could pave the way for solutions that sustain interaction quality over time, beyond just initiating encounters, and that support long-term relationships like family ties and friendships, vital for personal development and well-being [30, 36, 43].

In this paper, we aimed to explore how a conversation-supporting intervention could enrich collocated social interactions. We address the following research questions:

- **RQ1:** *How does a conversation starter intervention influence collocated interactions?*
- **RQ2:** *What are the users' thoughts on conversation-starter interventions that track and support social interactions?*

To answer these questions, we designed a research artifact called Boost that functions as a conversational aid by monitoring dialogues and introducing relevant content during lulls, curated based on users' interests. Boost aims to enhance collocated interactions through engaging content informed by interpersonal dynamics. We evaluated Boost's impact on social interactions through an empirical study, contributing insights on using technology to facilitate sustained, meaningful social connections.

The experimental study involved 38 participants over 19 sessions, with a setup designed to emulate a natural social environment. We employed a between-subjects experimental design, observing a group with and without Boost to compare their experiences and interactions. This approach allowed us to directly assess the impact of Boost on the quality and dynamics of the participants' social interactions.

After completing these sessions, we conducted semi-structured interviews with experimental group participants to gather in-depth feedback about their interaction with each other and the artifact. These interviews provided valuable insights into the participants' perceptions and Boost's influence on their social engagement and conversation quality. Through these interviews, we captured reflections on the role of technology in facilitating social connections and the potential benefits and challenges of using such interventions in real-world settings.

In this paper, we contribute to the existing work on collocated social interactions with a research artifact (artifact contribution) and user insights with design implications (knowledge contribution). Our findings indicate that Boost can increase conversational engagement and influence the dynamics of social interactions. Our study provides valuable insights into users' perceptions of Boost, highlighting ambivalence towards feedback mechanisms, the balance between intervention and privacy, and the possible roles of silence in social interactions. Furthermore, we propose three design implications for technological interventions aimed at improving collocated social interactions: 1) Develop context-aware nudges that respect the nuanced nature of social interactions, distinguishing between moments that benefit from intervention and those where silence is meaningful. 2) Implement multimodal feedback that balances informativeness with non-intrusiveness and accommodates diverse user preferences and sensitivities. 3) Design technologies that proactively invite user engagement, emphasizing automatic activation and ambient awareness to promote natural integration into the social setting.

2 RELATED WORK

2.1 Collocated Social Interactions

Social interaction is an essential aspect of well-being [40]. Although the absence of meaningful social interaction can adversely affect individual well-being, previous research underscores the benefits of social connections, demonstrating that interactions with close contacts nurture happiness [40]. Findings suggest that satisfaction levels are highest following interactions with friends, then family, acquaintances, and colleagues [24]. Furthermore, studies incorporating personal and external observations of social engagement reveal that individuals report increased happiness and a sense of social connectedness as they engage more frequently with others [36]. The quality and supportiveness of these relationships are also directly correlated with improved well-being [23].

The importance of collocated interactions extends beyond digital communication means such as emails, texts, or social media posts. Although digital platforms offer a sense of community and connection, it is through direct, collocated interactions that we derive crucial social support and foster genuine connections [38]. Engaging in face-to-face exchanges, whether sharing insights, offering or receiving advice, or gaining new perspectives from peers and family, is fundamental to building rapport, enhancing a sense of belonging, developing resilience, and aiding in emotional and informational processing to prevent cognitive overload. Such interactions are instrumental in not only improving self-esteem but also improving our ability to empathize and interact with others effectively [31]. Even casual conversations about mundane topics such as weather have been found to positively impact cognitive functions, similar to mental exercises [46]. Research further illustrates the necessity of interpersonal communication for health [45], drawing connections between social engagement and improvements in conditions ranging from cancer to depression to the common cold, highlighting the therapeutic effects of discussing personal issues, feelings, and views with others. This communication reduces feelings of resentment and stress, and contributing to better mental and physical health outcomes. Thus, it becomes evident that social engagements with various groups, including family, friends, and colleagues, are indispensable for sustaining and enhancing individual well-being.

2.2 Enhancing Collocated Interactions

Recently, HCI research has increasingly focused on improving the collocated social interaction amongst people by developing solutions with various approaches. These interventions leverage new ways to facilitate ongoing social situations, enrich means of social interaction, and support a sense of community, thereby promoting more meaningful and engaging in-person connections.

Previous work suggests interventions and solutions to mitigate the negative effects of low-quality social interactions, such as stress, disconnection, and feelings of exclusion. For instance, PicoTales facilitates the co-creation of stories in collocated settings, encouraging active participation and shared experiences among participants [33]. Similarly, Conversation Clock offers visual feedback on conversation dynamics, fostering awareness and balance in verbal contributions [5]. Technologies such as FishPong [47] and CueSense [18] serve as icebreakers, enhancing social interaction among strangers or in new encounters. Similarly, a wearable tool, CommonTies, aims to be a matchmaker amongst the conference attendees while finding their common interests. Additionally, devices like BubbleBadge [12] and Social Devices [19], Whisper [14] provide supplementary information or suggest topics for discussion, enriching social interactions and revealing common ground among participants.

A particular area that demands attention is the development of solutions that sustain the interaction beyond its initiation. While current research has predominantly focused on initiating encounters, there is a pressing need to explore interventions that support the maintenance of long-term relationships, such as family ties and friendships, which are vital for personal development and well-being [30]. This focus aligns with the recognized importance of social interactions in promoting mental health and overall well-being, highlighting the need for interventions that not only facilitate the beginning of social interactions, but also contribute to their sustained quality and depth over time [36, 43].

To address these gaps, this paper takes a step towards evaluating the effectiveness of a technological intervention in supporting social interactions. Unlike previous efforts, Boost is designed to enhance collocated interactions during conversational lulls through audio prompts. With this study, we contribute to the ongoing discussion about the role of technology in fostering social connections. Our goal is to inspire future research that focuses on assessing the impact of such interventions, addressing specific user needs, and supporting the continuity of meaningful social interactions.

3 DESIGN OF BOOST

Boost is a conversational tool designed to improve social interactions in collocated meetings by targeting lulls in conversations. It identifies moments of silence in conversations and responds by presenting short, engaging prompts related to users' favorite movie and TV show genres. We chose this type of prompts since movies, and TV shows can serve as powerful media to facilitate social engagement, encourage discussion, and build social networks among young adults. This also helps us to find common topics amongst the session participants, by matching their movie and TV show interests during our experiment sessions.

Our design of Boost is informed by the work of Genç and Coskun [13], who found that conversational lulls often trigger smartphone use, making it difficult to reengage people in conversation. They observed this phenomenon in interactions between friends as well as new acquaintances. By offering timely and relevant audio feedback, Boost works to break silences and encourage meaningful conversations, thereby promoting a more interactive and engaging environment in social settings. With these features, Boost's aim is to prompt new conversations and heighten participants' awareness of the quality of their interactions.

Drawing on insights from two studies in the literature that focused on designing for collocated interactions, we designed Boost to embody a hybrid approach that fuses the categories proposed by these studies. Genç and Coskun [13]'s work, which emerged from workshops with professional designers, and Olsson et al. [30]'s literature review, both highlight the importance of technologies that enhance the quality of collocated interactions. Inspired by their proposed categories—*Enlighteners, Preservers, Supporters, and Compliers* [13], and *Enabling, Facilitating, Inviting, and Encouraging interactions* [30]— the light intervention in Boost acts as an 'Enlightener', subtly informing users of the opportunity to engage or reengage in social interactions, hence preserving the quality of the social setting (see Figure 1). Meanwhile, Boost's audio intervention operates as a 'Supporter' and 'Facilitator' by filling lulls in conversations with engaging content, thus directly facilitating and encouraging interaction (see Figure 1). This dual approach aims not only to preserve the flow of conversation but also to support and enrich the interaction, making it more likely that participants will engage in meaningful exchanges. The design of Boost is, therefore, driven by the identified need for interactive technologies that support social interactions, leveraging the insights from previous work to create a more engaging and connected social experience.

As for the Boost usage scenario shown in Figure 2, after users take their seats at a table, Boost initiates "listening" mode, monitoring for ongoing conversation. If it detects no active conversation for a preset duration (i.e., two minutes), it first attempts to engage the participants with a visual cue –a soft light meant to capture their attention and signal a suggestion to interact. If the conversation does not resume in one minute, Boost then plays an audio clip related to the participants' interests in movies or TV shows, hoping to boost dialogue. If the conversation resumes after either intervention, Boost returns to listening mode, ready to assist again if needed. However, if silence persists after the audio prompt, Boost extends the wait time before intervening again (i.e., doubling the wait time), allowing participants more space to naturally re-engage with each other. By combining visual and audio cues, Boost aims to not only preserve the flow of conversation but also to support and enrich the interaction, making it more likely that participants will engage in meaningful exchanges.

3.1 Prototyping

In our experiments, our goal was to provide the participants with an experience that was as realistic as possible. Driven by this goal, and inspired by the Odom et al. [28]'s concept of a research product, we developed a fully functional prototype (Figure 3) to offer user experiences that closely mimic real-life interactions.

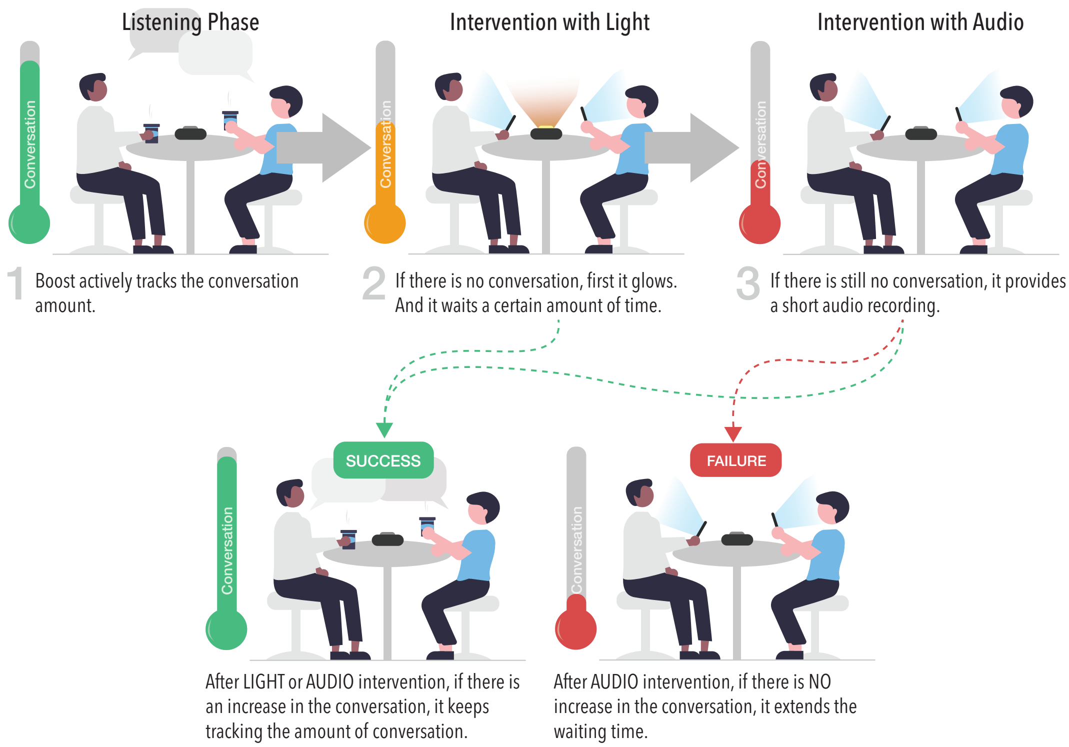


Figure 2: Boost Prototype Scenario - Boost actively listens and responds to moments of silence during collocated meetings, promoting engaging conversations through subtle visual and audio prompts.

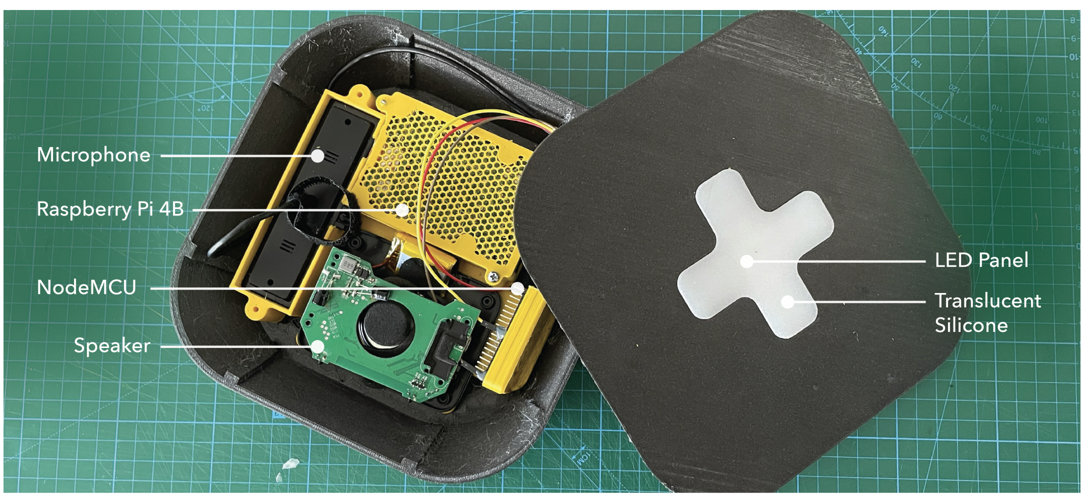


Figure 3: Internal components and layout of the Boost prototype. Key parts are labeled, including the Raspberry Pi 4B, NodeMCU, microphone, speaker, LED panel, and translucent silicone cover.

The design features a primary body with a translucent, rubber, plus-shaped surface on top (see figure 3). The prototype consists of several components: 1) a USB microphone to capture user speech, 2) a Raspberry Pi 4B to process and classify these conversations using a machine learning algorithm, 3) a NodeMCU development board to transfer data to the cloud, and 4) a speaker to emit auditory cues.

We integrated a pre-trained machine learning model, YAMNet [16], using TensorFlow Lite [1] for real-time audio classification within the Raspberry Pi environment. YAMNet, an audio classification model previously trained on Google's AudioSet dataset, can identify 521 distinct audio events. This capability is crucial in discerning speech presence in the audio data from the microphone.

Table 1: Example sentences for adventure genre

Audio Type	Example
`Popularity`	Adventure films became popular in Hollywood in the 30s and 40s with the films Robin Hood and Zorro.
`Example`	The Lord of the Rings series is one of the most successful and well-known examples of the adventure field.
`Cast`	When you think of adventure movies, Daniel Radcliffe and Johnny Depp come to mind with their serial films.
`Fun fact`	The Jack Sparrow character was inspired by pirate Yusuf Reis.
`Platform`	Uncharted, an adaptation of a video game series about the treasure hunt, can be watched on Netflix.
`Theme`	Some movies in the adventure genre focus on the theme of saving humanity. For example; Interstellar is about astronauts who set out to plug a black hole.

Table 2: Participants Demographics

	Group	**Mean** (Years)	Median	SD
Age	Control	21.06	21.0	1.83
	Experiment	22.0	22.0	2.18
	Total	**21.55**	**21.0**	**2.04**
Friendship Duration	Control	2.67	3.0	1.37
	Experiment	3.67	3.0	2.85
	Total	**3.19**	**3.0**	**2.29**

Our algorithm classifies audio data in real-time at one-second intervals. Based on this classification, users receive a prompt or nudge if they do not engage in conversation for a certain amount of time. All collected data is sent to the Arduino Cloud platform for storage. We prepared 90 sentences in six different styles from eight genres, recorded by three female and three male voices (Table 1).

4 STUDY

4.1 Experiment Setting & Participant Recruitment

The study took place in the design lab at our university. In the experimental room, we placed a couch facing a window overlooking a forest, our prototype 'Boost' on a coffee table, and several potted plants (Figure 4). This setup was intended to create a natural and comfortable environment for the users. We specifically recruited young adults, aged 18-26, in pairs for this study due to the prevalence of excessive smartphone use in this age group [2, 15] and the potential negative effects of this habit on their social interactions [13]. We invited participants through Koc University's online newsletter platform. With this announcement, we reached 21 individuals, and each participant was asked to bring their friends to the study, as we were interested in examining the effect of Boost on social interaction among acquainted individuals [30]. We recognize that Boost may be particularly useful in scenarios where social interaction is less natural, such as among strangers or individuals who find it difficult to start conversations. However, our study sample included participants with varying degrees of familiarity, ranging from three months to five years. This diversity allowed us to assess how Boost is perceived by different potential user groups, including both those who are intimately familiar with each other and those who are not. The study was approved by Koc University's ethics committee.

We conducted 21 sessions (1 Pilot, 10 Experimental, 10 Control) with these pairs. The first session, a pilot study, helped us finalize our experimental setup. We altered the couch arrangement during this session, leading to its exclusion from the study. Additionally, one participant in the control group sessions did not complete the post-questionnaire; hence, we excluded that particular session from our analysis. In total, 19 pairs (22 Females, 14 Males, 2 Other) participated. The average age was 21.55 (*SD*=2.04), with an average friendship duration of 3.19 years (*SD*=2.29) as shown in Table 2.

4.2 Experiment Procedure

We invited participants to a 90-minute study consisting of three stages. Participants were told that we were conducting a study of social interactions between them. Prior to the study, participants completed a brief questionnaire gathering demographic information, length of friendship, level of intimacy with each other (measured by one item for participants' perceived closeness to others), and preferred (top three) genres. This pre-study questionnaire aimed to tailor the content provided by the prototype based on participants' genre preferences. For example, by looking the dyads' genre rankings, we selected the common category, and set the prototype accordingly prior the study.

During the session, we welcomed participants into the experiment room and offered them coffee or tea. For those in the experimental group, we activated the Boost concept and waited for their interaction. In the control group, the prototype remained out of sight, but it continued to track and measure participants' conversations for subsequent analysis. We did not disclose the purpose of the prototype to any participant. A researcher instructed the participants to spend time in the room, explained the audio-video recorders, and then left the room. After 60 minutes, the researcher returned and administered a second questionnaire including a set of items which measures participants' perceptions their interactions (as used in Sprecher [35]'s work), Positive and Negative Affect

Figure 4: A snapshot from the Experimental setting for the Boost.

Schedule (PANAS) ([37], 10 items) to measure both positive and negative feelings, level of intimacy with each other (the same question from the pre-test stage), and two additional questions for measuring the depth (i.e., The conversation with my friend was deep.) and breadth (i.e., The conversation with my friend had breadth) of the conversation. This was to assess whether Boost influenced social interactions. We also conducted semi-structured interviews with participants in the experimental group to gather feedback on the concept and their thoughts, feelings, and concerns (e.g., How are you feeling now? What was the session like? What do you think of the experience? What are the positive/negative things about the experience?).

4.3 Analysis

During the experiments, we collected data from four distinct sources. First, we obtained self-reports from participants through pre- and post-experiment questionnaires. Second, the device categorized user interactions every second during the sessions and generated a separate CSV file for each session. These files contained data on lull moments, total speech ratios (amount of speech / duration of the session), nudge counts, and timestamps. We merged these two data sources into a single datasheet for descriptive [27] and inferential statistical analysis. .We assessed the normality of our data using the Shapiro-Wilk test, the equality of variances across groups with Levene's test, and checked for sphericity in our repeated measures data using Mauchly's test of sphericity. Since our data met the assumptions of normality, homogeneity of variances, and sphericity, we proceeded with various t-tests and ANOVAs using Jamovi 2.3.19 [17].

In addition, we installed a GoPro camera in the experiment room to take snapshots every 10 seconds (Figure 5) and used its live-stream feature for observational notes and participant monitoring. Finally, we audio-recorded post-experiment interviews, accumulating 285 minutes of material. We transcribed these recordings for analysis using MaxQDA 2022, software designed to efficiently organize, structure, and categorize large amounts of qualitative data. For the analysis phase, we used reflexive thematic analysis (RTA) [6–8], which allows for a thorough exploration of participants' experiences and opinions through an inductive approach. Initially, three researchers familiarized themselves with the data through transcripts and then collaboratively refined initial codes. We organized the quotes into seven main groups (e.g., methods of interacting with Boost) and developed 268 subcodes (e.g., "Activating the device implies a need for it"). Finally, we grouped all codes thematically into four categories, which are presented in the following section.

5 RESULTS

Combining our session observations with the user interviews, we found that Boost reduced silent moments in conversations and enriched collocated social interactions. We found that it not only sparked conversations but also encouraged users to reflect on the quality of their interaction. Furthermore, participants' reactions to the concept indicated a tendency to prefer collaborative and automatic mechanisms for initiating conversations. Finally, we discovered that silence in conversations is not necessarily bad, and may even be desirable for high-quality social interactions. In the remainder of this section, we elaborate on each of these findings.

5.1 Reducing silent moments and enhancing user interactions through technology

We conducted an independent samples t-test to compare speech ratios in different group types. The speech ratio in the control groups (M=0.59, SD=0.14) was significantly lower than in the experimental groups (M=0.76, SD=0.08); $t(36)=4.38$, $p < .001$ (Figure 6a & 6c). In addition, lulls were significantly more frequent in the control group than in the experimental group, $t(36)=3.67$, $p < .001$, (control (M=8.77, SD=6.82), experiment (M=3.60, SD=3.01)) (Figure 6b & 6d). These results suggest that dyads who received nudges from Boost engaged in more social interaction.

Figure 5: Comparative snapshots from the study sessions. Top) Experiment groups with the Boost. Bottom) Control groups without the Boost device engagement.

As can be seen in Figure 5, most of the participants used their smartphones when they were not interacting with each other. In this study, we do not measure the amount of smartphone use as in Brown et al. [9]'s work, but according to our observations, during the lull moments, the use behavior was prominent among participants in both the experimental and control groups. However, with the finding that lull moments were significantly higher in the control group, this use behavior was also frequently observed in the control group participants. Consistent with these findings, the majority of experimental participants reported that Boost had a positive impact on their interactions (N=15/18). Taken together, these results suggest that Boost minimizes silent moments in social interactions, promotes participant engagement, and potentially prevents participants from engaging with their phones.

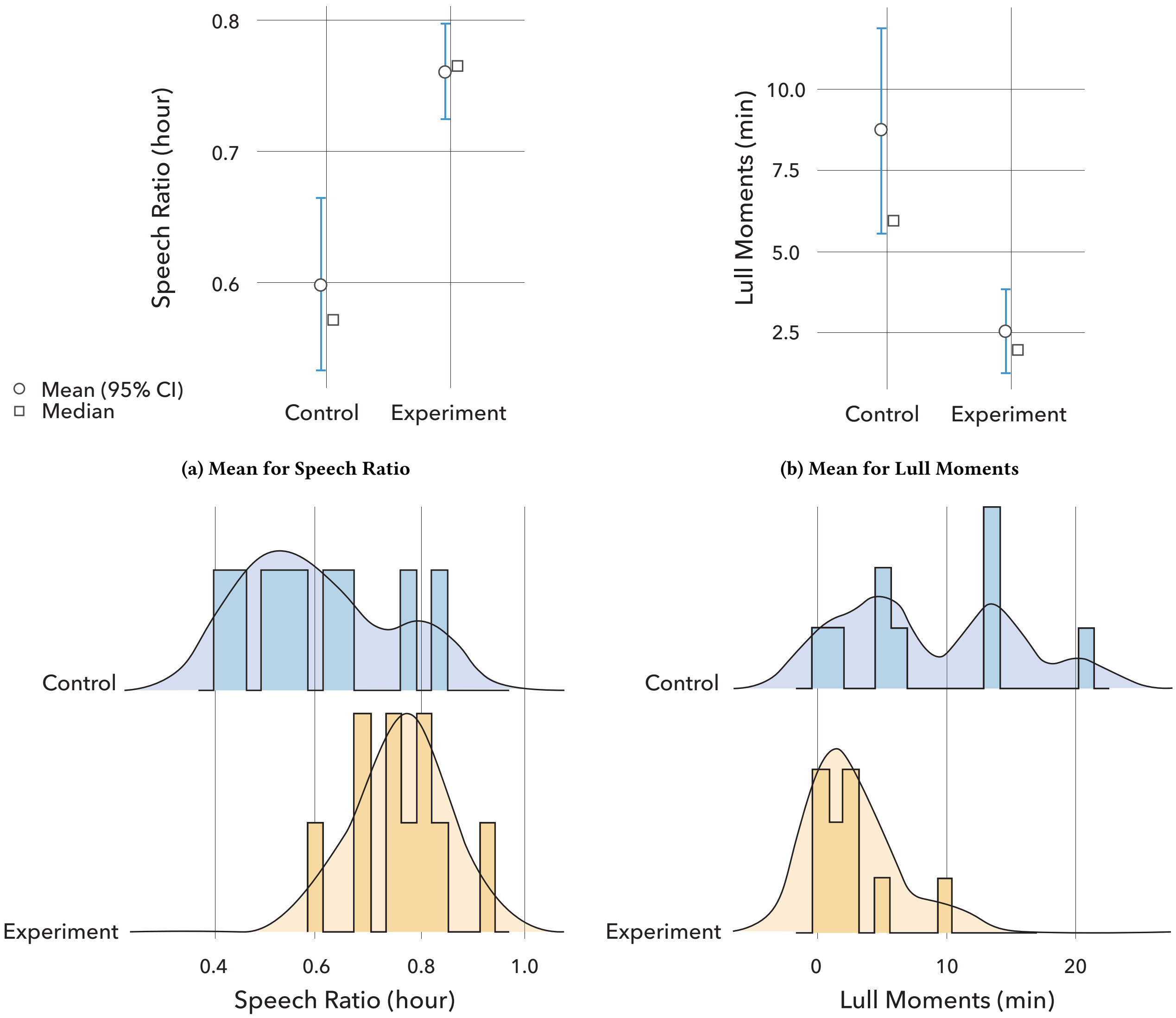
We identified three different ways in which Boost initiated conversations. First, participants directly discussed the topic provided by Boost (e.g., a sentence about 'Dune' led to a discussion about the movie). Second, conversations began with the Boost-provided topic and then evolved (e.g., starting with 'Dune' and moving to personal movie preferences). Third, participants perceived the audio nudges as feedback on the quality of their conversations, prompting them to initiate different topics (e.g., after a prompt about 'Dune', they discussed global economic changes). These observations illustrate the richness of Boost's contribution to enhancing collocated interactions by keeping users engaged in conversations.

Furthermore, users found it helpful to hear key phrases rather than full sentences to start a conversation. While these prompts often started conversations on the suggested topic, they also led to discussions on personal topics. For example, one dyad who had known each other for three months discussed the cast of "Dune" before moving on to personal preferences for actors. Another participant found this a valuable opportunity to explore common interests and deepen mutual understanding.

This aspect of discovering common interests led to discussions about Boost's target audience. Several groups noted that people who were less familiar with each other experienced more awkward silences, suggesting a potential need for such technology to facilitate conversation in these situations.

We calculated Spearman's rank correlation to examine the relationship between the duration of friendship and speech ratio. Contrary to expectations, we found a significant yet negative correlation between these variables, $r(17) = -.44$, $p = .03$, indicating that speech ratio decreases as friendship duration increases (Figure 7).

To further explore the issue of finding common ground, we measured intimacy levels before and after the experiment and found a statistically significant difference between the experimental and control groups ($F(1, 36) = 4.58$, $p = .03$). In addition, the PANAS scores revealed significant differences between groups ($F(1, 36) = 4.94$, $p = .03$), where negative emotions were significantly lower in the experimental groups (11.5 ± 0.37) than in the control groups (16.06 ± 2.12). However, there was no significant difference in positive emotions, although the experimental group had a higher average (13.5 ± 0.46) than the control group (10.2 ± 0.52, $p = .07$).



(a) Mean for Speech Ratio

(b) Mean for Lull Moments

(c) Distribution of Speech Ratio

(d) Distribution of Lull Moments

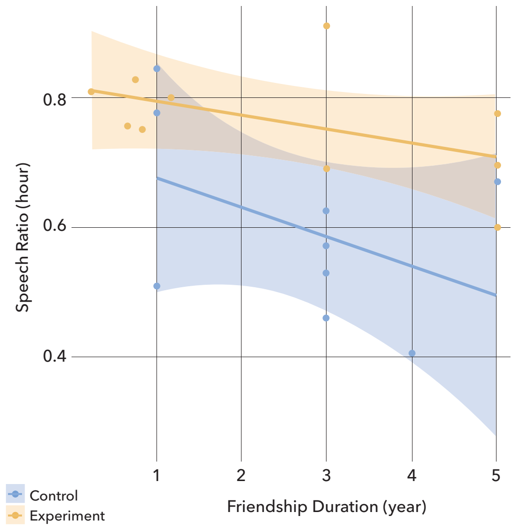
Figure 6: The mean and the population distribution for Speech Ratio and Lull Moments.

Overall, these results indicate that Boost affects users' speech rate, frequency of lulls, negative emotions, and, intimacy levels. Specifically, Boost appears to have the potential to increase conversational engagement and reduce negative emotions in collocated social interactions.

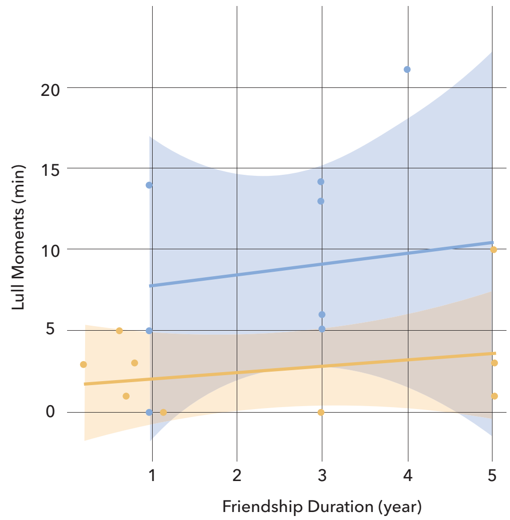
5.2 Ambivalent nature of receiving feedback and nudges for quality of social interaction

Boost is perceived as a companion that individuals can carry as a personal device. Some users elevate Boost to the status of a friend who is always ready to engage in conversation and encourages others to do the same. They highlighted that treating this product as a companion can provide relief to those who are eager to talk or feel nervous about speaking in front of others.

Beyond Boost's ability to facilitate conversations, users report receiving feedback on their interactions, offering both supportive and critical views. Interestingly, most of the negative feedback concerns the use of light for communication. Users find the audio medium more intrusive, while they can easily ignore a visual medium. This contradicts earlier expectations for visual rather than auditory feedback, as noted in a previous study [14]. In exploring users' perspectives on this issue, a primary concern is that light merely signals feedback, highlighting their failure to communicate with friends. In contrast, they feel that sound provides a different kind of support:



(a) Speech Ratio vs. Friendship Duration



(b) Lull Moments vs. Friendship Duration

Figure 7: The interaction between Speech Ratio/Lull Moments and Friendship Duration

> *"The sound makes an effort. It actually helps you. Right there, when the conversation quality drops, it suggests, 'Here's a topic you can talk about,' but light is more like, 'There's a problem,' you know?" (P5)*

However, this perception is not solely due to the modality but also the nature of the feedback. While the light acts as a single-message signal (i.e., a warning about low quality interaction), audio feedback offers a content that contributes to the conversation. Additionally, another user noted the destructive potential of feedback on personal relationships:

> *"Imagine sitting with a close friend or partner, and then the device lights up. It's stressful. 'Do we have a problem? Can't we communicate? Should we get therapy? Is our relationship over?' It can be devastating. 'We can't establish healthy communication, you know? The light is on now!'" (P14, simulating a conversation)*

Users also express concerns about the light's impact on dyadic relationships and its negative effect in public settings. In their view, a device like Boost lighting up in a café to indicate a drop in interaction quality could expose their 'failures' to others:

> *"This light seems to cause a lot of social anxiety. You see the device, and it creates a perception in a social setting about us. A sign of 'How well do we interact?'" (P6)*

Furthermore, participants who used their smartphones during the sessions noted that the light catching their attention prompted them to disengage from their phones. They viewed this as a positive cue to return to social interactions. In contrast, three participants mentioned that the light turning on after social interaction falls below a certain level stresses them. They found a simple warning about low conversation levels insufficient and uncomfortable, seeking more effective solutions:

> *"[Regarding the light] It made me very nervous. Seeing the light on, I felt pressured to speak. I think a direct contribution without a prior feedback would be better." (P7)*

In addition to feedback and nudges to invite users into a social interaction, users also expressed their concerns about collecting their personal data (e.g., their movie history, genre preferences) and device listening to conversations between users and the environment. Many users discussed how and how much of their data is collected, where it is used, and how it is kept secure. In addition, participants felt that having their conversations listened to and processed by this device was very unsettling and could have a negative impact on their level of disclosure to others.

In summary, these observations and participant statements indicate that Boost prompts people to reflect on the quality of their social interactions. However, participants were ambivalent about how this reflection was triggered. While some perceive Boost's nudges as negative, others see them as a good opportunity to reflect and adjust their behavior.

5.3 Control, agency, and right to intervene in social interaction

In our study, Boost tracked users' interactions and provided light and sound nudges based on the continuity of conversations. When we designed the prototype, we envisioned that users who wanted to activate Boost would need to place their smartphone on the plus-shaped area on top of the device since one of the possible distractions for social interactions is smartphones [13]. With these actions, participants would stay away from their devices during their social interactions. However, most participants (N=16) found it inappropriate to activate a device designed to nudge low social interactions, describing such an action as shameful.

"It may be shameful, but it depends on how close we are. For instance, if I'm not interested at the moment, I'd do this [placing her smartphone on the device] instead of telling a friend to 'put down your phone'. I think that's poor communication, you know?" (P9)

When discussing this scenario, some users noted that intentionally activating such a device implies "an expectation of poor social interaction" for the person who activates it. In addition, users (N=11) emphasized that Boost should be activated with everyone's consent, not just one person's decision. They also preferred automatic activation when sitting at the table.

A few users (n=4) suggested adding a snooze function to Boost. They recommended that the device should not only respond to user preferences but also be context-aware and act by measuring certain criteria, such as the seriousness of the conversation or reasons for silence.

Users generally appreciated Boost's environmental awareness and gradual reduction of nudges and rated its effectiveness. One participant suggested that all user-interactive products should include such a feature. For example, smartphones using a similar algorithm for notifications could significantly reduce daily distractions.

Three users were unsure about Boost's capabilities when they first encountered it. One highlighted its visibly distinct, non-distracting, yet interesting design, stating that it should avoid appearing small and sneaky.

"It's much better this way than being small and sneaky. I felt it was joining us at the table. It's quite noticeable that there's something here. It's like the design is saying, 'There's something on this table you should be aware of.' I'd sit down and accept whatever it offered. However, I'd feel anxious if it were less conspicuous and suddenly started making noise from under the table." (P4)

These findings illustrate that intervening in a social setting to enhance collocated interactions is a complicated task that requires a delicate balance of control between users and technology.

5.4 Silence is also good in terms of social interactions.

The majority of participants (N=32) emphasized that the quality of interaction should not be measured solely by the quantity of conversation. They expressed that pleasant experiences are possible even in the absence of verbal communication. Specifically, three participants mentioned that they consider these individuals to be close friends with whom they can comfortably share silence.

Nine participants noted that moments of silence with acquaintances or less familiar friends are often uncomfortable. In contrast, they perceive silences shared with close friends as meaningful, potentially inclusive activities, such as observing people in a coffee shop.

One participant described this phenomenon as a cyclical process, explaining that her current ability to sit in comfortable silence with a friend was a gradual development, nurtured by their early conversational interactions.

"In essence, we have reached a level where silence is comfortable, achieved through prior conversations. It seems we have cultivated the capacity for silence, initially by sharing quiet moments within our talks. These aspects are mutually reinforcing and intensify each other." (P9)

Another interesting example was a session where a dyad in the experimental group thought that Boost was triggered by their physical movements and interactions with objects in the room. This session, marked by minimal conversation but intense exploration, saw the highest frequency of nudges from Boost. Despite this, participants reported considerable enjoyment in deciphering Boost's operational logic.

These results show that technologies like Boost can be very useful in environments like restaurants, cafes, and school cafeterias and for people who have just met each other to enhance collocated conversations. On the other hand, they showed that measuring the quality of a social interaction, i.e. the level of enjoyment and pleasure derived from it, should involve more than just detecting and interrupting silence.

6 DISCUSSION

In this section, we discuss the implications of our findings for designing technologies to enhance social interactions. We present the significance of context-aware nudges, the intrinsic value of silence in social dynamics, and the critical balance between technology's role in augmenting vs. overshadowing natural social exchanges. Our investigation further explores multimodal feedback mechanisms that respect user preferences and the importance of designs that proactively engage users without undermining their autonomy or privacy. Additionally, we reflect on the broader implications of technology-mediated social interactions, addressing the challenges of privacy, the potential for artificiality in interactions, and the insights gleaned from employing a research artifact to probe deeper into the complexities of human social behavior. Although these implications confirm previous work in this field, they also indicate new insights. In the remainder of this section, we explicate them by comparing them with previous work.

6.1 Design Implications for Technologies Aimed at Enhancing Social Interactions

6.1.1 Nudges should discern between detrimental and meaningful silences. Our research has reaffirmed the importance of context in assessing the quality of social interactions [22], particularly highlighting instances where silence does not necessarily signify poor interaction. Findings suggest that while tracking silent moments can offer insights into interaction quality, it is not a fail-proof method, as corroborated by previous studies [13]. Our analysis extends beyond the functional aspects of silence, recognizing its intrinsic value in facilitating deep and meaningful social connections. This finding echoes Johannesen [20]'s the 'typical potential meanings' of silence in interpersonal communications. In his work, silence can reflect 20 different meanings, including "empathic exchange, the companionship of shared mood or insight," "boredom," or "punishing others". As our findings revealed, especially among close acquaintances or in reflective contexts, silence can also have meaning and enrich their social interactions.

Although the importance of silence in social interaction, particularly among long-term acquaintances, may not sound surprising, we discovered that applying nudges based on these silent moments often led to unintended disruptions in user activities. For example, an incident was observed where users were interrupted by a device nudge while sharing content on their smartphones in silence, illustrating that such nudges could inadvertently hinder rather than facilitate meaningful social engagement.

This underscores the need for technology that can intelligently discern between different types of silence –distinguishing between those that signify a lapse in interaction and those that are part of a meaningful exchange. A refined approach could involve focused metrics that consider the context of silence, such as the nature of the ongoing activity, the emotional state of the participants, and the depth of their engagement. By integrating these factors, technology can better identify moments that genuinely require intervention to foster social connection and those where silence is a valuable component of the interaction. Therefore, it is imperative for future HCI systems to not merely focus on minimizing silence but also to acknowledge and preserve its significance. Developing algorithms to discern the qualitative differences between comfortable and uncomfortable silences by analyzing conversational context, participant behavior, and ambiance can enhance system sensitivity to human social nuances.

Moreover, the implementation of these systems must prioritize user privacy [44] and autonomy [4, 10], offering customizable intervention preferences to accommodate individual variances in comfort with silence. This approach honors personal preferences and acknowledges the diverse nature of meaningful interactions between different individuals. By aiming to augment rather than overshadow natural social dynamics, technology should aspire to integrate into the fabric of human interaction seamlessly, offering felt support that is not obtrusive. The ultimate goal is to complement the natural rhythm of social exchanges, preserving the integrity and richness of conversation and silence.

6.1.2 Utilizing Multimodal Feedback that Balances Between Being Informative and Non-Intrusive. Genç et al. [14] assessed their prototype, which was based on giving audio cues to initiate a conversation, and found that some users would like to see visual cues as they thought that an audio cue could not be noticed in a crowded environment such as a cafe. Inspired by this finding, we designed Boost as a device that uses both audio and visual cues. Our findings highlighted the contrasting perceptions of audio and visual feedback. While audio nudges were seen as helpful conversation starters, visual feedback was often perceived as intrusive and stress-inducing. This contrasts with their findings. However, this does not mean that multimodal feedback during social interactions are entirely useless. For example, in their work, Ménélas et al. [26] revealed that audio and haptic feedback can effectively reduce the load on the visual channel in an acquisition task in a multi-target context. This suggests the need for multimodal feedback in HCI designs that balance informativeness with non-intrusiveness, taking into account different user preferences and sensitivities.

Designs should incorporate adaptive feedback mechanisms that can switch between or combine different modalities (e.g., audio, visual, haptic) based on the context and user preferences. For example, in more public settings, subtler feedback modalities like haptic signals could be more appropriate, whereas in private settings, audio or visual cues might be more effective.

Additionally, the feedback should be designed to be perceptive and responsive to the users' current engagement levels. If a conversation is flowing well, feedback should be minimal or absent. Conversely, feedback should be gently encouraging but not coercive during extended lulls. It is crucial that the feedback does not detract from the quality of the interaction but rather enhances it subtly.

6.1.3 The designs should invite the user rather than wait for their initiation. Our insights regarding Boost's activation revealed users' discomfort with visual feedback (i.e., visible, unhelpful feedback) during social interactions. Most of the participants favored automatic device activation without requiring explicit user initiation. This preference emphasize the importance of designing interactive technologies that invite engagement rather than passively waiting for user initiation.

Designs should subtly signal their readiness to assist while avoiding any implication of poor interaction quality. For example, incorporating ambient awareness and responsive activation can make the technology feel more like a natural participant in the social setting. Furthermore, the device should clearly communicate its purpose and functionality, avoiding misconceptions or unintended social stress.

In addition, inviting designs should consider user preferences and scenarios, offering options for customization. This approach respects the autonomy of the user and promotes a more personalized and comfortable interaction with the technology. The goal is to create designs that seamlessly integrate into the social fabric, enriching interactions without imposing themselves on the users.

6.2 Navigating the Intersection of Technology and Social Interactions

6.2.1 Understanding social interactions through technology. We designed Boost to enrich social interactions by detecting lulls and triggering collocated social interactions. Our study revealed its potential positive effects on users' social interactions, but it also raised concerns. Although all participants acknowledged that enriching social interactions benefits users' well-being, some perceived a product designed for this purpose as dystopian.

Parallel to this, in our findings, issues of privacy and the artificiality of mediated interactions also surfaced. Most of the respondents believed that any device that aids in their social interactions should be customized to their needs. As highlighted by Windl and Mayer [44], this requirement implies the need for collecting digital footprints or real-time monitoring and interpretation of user data, sparking concerns about privacy and artificiality, with the broader concern that privacy anxieties persist across device types, particularly those with audiovisual recording capabilities. In line with the findings of Windl and Mayer [44], participants feared that constant monitoring could affect their social interactions and inhibit their freedom of expression, resulting in artificial interactions. They said that they could not open up and behave naturally in an environment where they sensed surveillance. Ironically, a device intended to enrich social interactions might instead negatively impact them due to perceived privacy issues. This paradox underscores the importance of considering multiple perspectives in designing behavior change technologies, as unintended consequences can arise from these interventions [41, 42].

In addition, despite assurances that our prototype did not collect or store data, some participants still mistrusted the device. Moreover, they emphasize that they would show lower privacy concerns for devices they own and are familiar with, as echoed by Apthorpe et al. [3] and Windl and Mayer [44]. This suggests that some privacy concerns expressed by our participants may diminish as they become more accustomed to Boost and its functionalities. It implies a potential path forward for designers: fostering familiarity and trust in new technologies can mitigate privacy concerns over time.

6.2.2 Designing Technological Artifacts to Interfere with Social Interactions. In this study, we employed a research artifact (i.e., Boost) [28]. We presented this artifact not only as a final product but also as a tool to stimulate users' imagination and gain deeper insights into their collocated social interactions and their responses to the designed nudges to improve the quality of these interactions. As an illustration, this approach highlighted that providing only feedback on personal behavior (e.g., visual nudges at low levels of social interaction) could make users uncomfortable, highlighting the need for more supportive interventions (e.g., conversation starters). Including the artifact during the experimental sessions and the in-depth discussion during the interviews allowed users to better contextualize their experiences, enriching our understanding of their social interactions.

While our prototype was instrumental in the research process, it led to a deeper understanding of the problem space, revealing several issues with the design assumptions behind such technologies. For example, Boost's presence was frequently seen as an indicator of poor interaction quality, —potentially—labeling silent moments as negative rather than as a natural aspect of social comfort, especially among familiar pairs. This observation challenges the assumption that less silence automatically equates to improved social interactions.

Moreover, we noted that the Boost concept, as a research tool, became somewhat obsolete as the study progressed. Participants often utilized the experiment time to socialize and reconnect naturally, highlighting the value of uninterrupted conversations and the positive emotions reported by the control group, who did not even use the prototype. We initiated this project with positive intentions, aiming to design a device to support face-to-face interactions and reduce excessive smartphone use. In essence, we attempted to solve a problem by introducing a new technology, Boost. However, our study results suggest that introducing new technology could also create new problems, such as labeling interactions as "poor" or making participants feel interrupted by the technology itself. This aligned with the concept of *wicked problems* in design, where solving one problem often leads to the emergence of others [32].

These observations raise critical questions regarding technological interventions in co-located interactions: Do we really need a device to remind us of the value of our social interactions? Should HCI practitioners actively interfere in natural social processes, or do such interventions lead to more harm than good? How can we support organic social interaction without over-curating it through technology? Where should we draw the line between giving users full control and intervening in their interactions? These questions remain open for future exploration and are important for guiding the design of technological interventions in social settings.

7 CONCLUSION

Social interactions are crucial to people's lives. These interactions have changed with the widespread development and use of technological devices such as smartphones in our daily lives, and the low quality of social interactions has detrimental effects on users' psychological, physiological, and social wellbeing. In this paper, we present Boost, a design artifact that aims to enhance people's social interactions by tracking the interaction and supporting with movie-related audio trivia, and an experimental user study that evaluates users' reactions to this concept, its potential impact on users' social interactions. We recruited 38 participants (19 dyads) and conducted one-hour sessions with the experiment and control groups. In addition to the experiments, we conducted semi-structured interviews with users who had experienced the concept. Our findings suggest that Boost helped reduce silent moments and some negative feelings, while also encouraging deeper engagement between users.

Reflecting on the broader implications of our study, it is clear that technologies aimed at enhancing social interactions should navigate a complex landscape of user expectations, privacy concerns, and the intrinsic value of natural social dynamics. Our participants' reactions to Boost revealed a preference for non-intrusive, context-aware nudges that respect user autonomy and privacy. This highlights the importance of designing interventions that use multimodal feedback to provide support that is both perceptive and responsive. In addition, our findings highlight the critical need for privacy-preserving measures in technology development, as concerns about data collection and surveillance can undermine the benefits of such interventions.

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