

CoListen

Michael C. Stewart

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Deborah G. Tatar, Chair
Margot Brereton
Kurt Luther
D. Scott McCrickard
Steve R. Harrison

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CoListen

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(ABSTRACT)

Humans need to feel connected to one another. With each new technology we create and re-create ways to connect with others we care about. Thanks to the ubiquity of powerful mobile technology in certain parts of the world, we have nearly immediate access to those remote others. Despite these advances our shared experiences are diminishing, and the ways we most often connect with our remote family members seem to be superficial and at the expense of more meaningful interaction with collocated family members.

People are not likely to give up the convenience and entertainment afforded by their mobile technology, but might those same technologies be capable of supporting interactions that help the users be the selves they wish they were, rather than the consumers their technologies were designed to support?

To investigate the space of technological support for people's feelings of togetherness I conducted three studies. The first study was a diary study over 14 days where I asked about the current practices of middle schoolers for communicating with friends out side of school and for listening to music. In the second study, I conducted a design charrette where participants designed a technology to support co-listening, and then tried my first prototype.

CoListen is a streaming music player that supports a listener in listening to the same music at the same time as a friend or family member. CoListen is designed with the explicit intent of requiring as little of the listener's attention as possible. In the third study, I deployed Colisten v1.0 in the wild and conducted a 14-day diary study asking participants about their experiences.

I found that many of the participants from my target population listen to music and communicate with their friends, and that phatic communication (as opposed to goal-oriented communication) was prominent. I also found participants to be interested in the idea of technology to support co-listening and intrigued by how few little the barrier to co-listening can be, and how little attention is required. In study 3 I found that people enjoyed the experience of remote co-listening and did listen to music as a background activity. Many participatns reported feeling more together with their family members with whom they co-listened.

CoListen

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(GENERAL AUDIENCE ABSTRACT)

Humans need to feel connected to one another. With each new technology we create and re-create ways to connect with others we care about. Thanks to the ubiquity of powerful mobile technology in certain parts of the world, we have nearly immediate access to those remote others. Despite these advances our shared experiences are diminishing, and the ways we most often connect with our remote family members seem to be superficial and at the expense of more meaningful interaction with colocated family members.

People are not likely to give up the convenience and entertainment afforded by their mobile technology, but might those same technologies be capable of supporting interactions that help the users be the selves they wish they were, rather than the consumers their technologies were designed to support?

To investigate the space of technological support for people's feelings of togetherness I conducted three studies. The final study involved participant using a custom-built streaming music player app that supported friends and family members in listening to the same music at the same time. This app was also designed to require as little of the listener's attention as possible.

I found that many people reported feeling more together with their friends or family with whom they co-listened.

Dedication

Emily,

Thank you my Sweet Love. When I applied to graduate school we were not yet engaged, and now that my Ph.D. is nearly complete, we have been married seven years and have our two wonderful children Mary and Charlie. I could not have done any of this without your love and support. Your love for me, our children, and your students inspires me. Your hardwork to excel in an exceptionally difficult career helped motivate me to press on when my work was challenging.

I hope I can make the kind of difference in the life of my students that I see you making in the lives of yours. In these difficult times, knowing that you are teaching children gives me hope for our future.

—

Now my feet turn the corner back home

Sun turns the evening to rose

Stars turning high up above

You turn me into somebody loved

Michael

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List of Abbreviations

- ABCCT** Affective Benefits and Costs of Communications Technologies. [xiii](#), [xiv](#), [54](#), [59](#), [61](#), [79](#), [80](#)
- API** Application Programming Interface. [26](#), [48–51](#), [66](#), [87](#)
- APNS** Apple Push Notification Service. [45](#), [48](#), [87](#)
- CSCW** Computer-Supported Cooperative Work — a sub-field of HCI under which much of the current work might be categorized —. [10](#)
- family** friends and/or family members. [xiii](#), [4](#), [13](#), [56](#), [59](#), [62](#), [67](#), [71](#), [72](#), [81](#), [83](#), [84](#), [86–88](#)
- GUI** Graphical User Interface. [45](#)
- HCI** Human Computer Interaction. [2](#), [10](#)
- ICT** Information and Communications Technology. [xiii](#), [5](#), [61](#), [81](#)
- ICTs** Information and Communications Technologies. [4](#), [13](#), [21](#), [22](#), [25](#), [40](#), [61](#), [71](#), [72](#), [81](#), [89](#)
- IDE** Integrated Development Environment. [45](#)
- IM** Instant Messaging. [40](#)
- iOS** Apple, Inc.’s mobile operating system. [26](#), [45](#), [48–50](#), [61](#), [66](#), [86](#), [87](#)
- IRB** Institutional Review Board. [16](#), [29](#)
- KIT** Keep In Touch. [xiii](#), [18](#), [20](#), [34](#), [71](#), [72](#)
- MP3** Ubiquitous format for sound files. Used in marketing to mean a file containing a song.. [1](#), [2](#)
- n.b.** *nota bene*, take special notice. [58](#)
- OS** Operating System. [26](#), [86](#)
- PC** Personal Computer. [24](#)

SDK Software Development Kit. 26, 45, 49, 50, 54, 66, 87

SMS Short Message Service — the technical name for “text messaging” via mobile telephone —). 3, 25, 40, 59, 61, 67

USD United States Dollars. 17, 30

VT Virginia Tech. 16, 29

Chapter 1

Introduction

The enjoyment of music is essentially a social experience.

— W. Ray Crozier
Music and social influence [24]

Despite today’s (developed) world of ubiquitous connectivity, people may question exactly how much meaningful connecting is happening over these connections. Where once consuming media used to bring us together, as in the early days of radio when families gathered around a radio set to listen to programs, now we so often consume media on personal electronic devices that we often isolate ourselves from others. For example, in office environments, proximate employees used to co-listen to a radio that might be located in one person’s cubicle. They would hear the same songs, the same talk shows, the same advertisements, and possibly participate in the same radio station concert ticket contests. While the employees were there to work, and largely attended to this work, they also shared in the experience of listening to the radio. In a similar setting today, we are not surprised to see each such cubicle worker, listening through their own headphones to their personal music library.

“The way we consume music is not simply about listening but involves the ways it becomes integrated into our personal and social lives. This is very much determined by the technologies through which we experience it: how music is distributed, rendered, purchased, organized, shared, chosen, listened to, interacted with, and repurposed.” [81]

Technology changes our relationship to others. The concept of a personal computer is, in fact, personal. The concept of a cell phone or an MP3 player is similarly personal. These are wonderful things. However, they create new places (audio environments) that may be isolated. There are many benefits to these; however, there are also drawbacks. Sometimes this isolation is desirable, as when people use technology to “cocoon” in public, “create a private space in a crowded environment, ... signaling that one is reluctant to be involved in any social interaction” [55, 71, 76].

However, people also seek connection. Current mechanisms for listening to music offer two primary choices: isolation (“...listening to music is mainly an individual experience.”[67]), or sharing with the entire complement of physically proximate people.¹ Sometimes people may want to listen to music, without completely isolating themselves.

In the past 100 years, the predominant means of listening to music has shifted from public, shared consumption of live productions to potentially shared consumption of recorded or broadcast productions, and, further, to private consumption. Small, widely-available, high-capacity devices offer users high-quality recordings, choice, and mobility. They also make music personal. The concept of a cell phone or an MP3 player is similarly individual. Furthermore, the ubiquity of headphones means that even when people listen to music in the presence of others, that experience may be private. While the increasing levels of privacy and choice afforded by the personalization of music listening technology are valuable. They seem to have required that we sacrifice listening to music together.

People listening to music constitute an important population to the **Human Computer Interaction (HCI)** community. Music listening is one of the most ubiquitous of human-computer interactions. Cell phones are ubiquitous and virtually all cell phones have music listening capabilities. People also listen to music on other devices in widespread use, such as iPods and MP3 players, tablets, and laptops computers. Although subscriptions are not necessary to use these devices to listen to music, there are over 170 million active Spotify users [102] and 27 million Apple Music Subscriptions [53].

Despite the prevalence of these devices, services, and practices and the potential they present for design, they are infrequently investigated in design-oriented research. Other related issues are explored, such as managing and sharing music libraries [19, 115] and engineering audio experiences [63, 91]; however, to our knowledge, Mainwaring et al. [71]’s work in large urban centers is one of the few projects that explores sociality in the everyday experience of listening to music on these devices or their potential for sociality.

1.1 Motivation

The primary motivation for the work starts with the observation that music listening is done increasingly with headphones. In the same way that our smartphones have turned many walkers’ heads downward, headphones have closed most listeners’ ears. Music-listening, an activity that has historically had major social importance as a shared activity, has recently become an isolated experience.

I report the exploration of the design space and the design, the implementation, and the use of a system to support the reconceptualization of the solitary audio environment of listeners as a shared one. This reconceptualization does not recreate the old shared environment of

¹The recent deployment of the Discord Spotify Connection [47] notwithstanding.

the home or coffee house, which depended solely on physical proximity.

Instead, it is targeted. It facilitates sharing the music-listening experience by allowing targeted others to listen at the same time, regardless of proximity. In supporting people's remote co-listening, it will be vital to balance their local needs with their remote needs. CoListen allows users to operate in the “zone of proximal connectedness,” meaning that they have the knowledge that they are listening with others whether that listening is in the foreground or the background of their current activity. It provides low-level, non-intrusive audio connection with others, reconceptualizing the “headphone” as a shared place with at least some of the richness of experience of collocated audio space. I am interested in studying the affective and relational effects of co-consumption.

1.1.1 Situations

CoListen may be desirable and have good effects in a myriad of different situations that involve a desire to be connected to remote persons whether the separation is for an evening, a day or for longer periods of time. I identify my primary and secondary populations of interest and then mention other candidate populations.

1.1.1.1 Middle Schoolers

Middle school children are the primary population of interest for CoListen. Middle schoolers live in a complex technological world. In general, middle schoolers may consider the social aspect of their lives paramount to most other aspects. On the one hand, many of today's middle schoolers may feel that maintaining their relationships requires that they be constantly engaged with their mobile devices to communicate via various (allegedly) asynchronous means such as **Short Message Service — the technical name for “text messaging” via mobile telephone —** (SMS), WhatsApp, or Snapchat. This has benefits, but it also poses problems. First, it may not succeed in creating the desired feeling of connectedness. Second, as they feel they must remain attentive to their phones [114], and through it, their friends, they may have trouble attending to other, physically collocated people or activities at home. Third, while they may feel the need to be fully engaged with digital devices, not all of them have such devices or may not be allowed access to those facilities when they are asked, for example, to be focused on homework. On the other hand, other sources of sociality may not be obtainable. In rural and semi-rural areas, or others with unsafe cycling conditions, children who cannot drive or do not have cars are essentially as immobile as older adults in other communities [73]. They cannot easily hang out.

Although co-listening is unlikely to offer the overt satisfaction of asynchronous connectivity, it may offer some of the benefits without requiring constant attention. Co-listening may afford middle schoolers a way to feel connected with each other that might require little of

their attention be diverted from other activities. It may offer a way of connecting, a bit, when other connectivity is undesirable or unobtainable.

I believe that this population would benefit from a co-listening system. Further, in my review of the literature, this population is under-studied for the potential benefits from technological support for keeping in touch with their peers.

1.1.1.2 Students in Higher Education

Students in higher education constitute a secondary population. In fact, they may also be isolated and similarly interested in social connection and support. Undergraduate students in the United States typically matriculate to institutions that are relatively far from home and their complex schedules and heavy work and school burden may make regular interaction even with local friends difficult. In a 2015 survey of “first-time, full-time freshmen”, nearly 20% of respondents attending public 4-year colleges matriculated to schools over 500 miles from their permanent home, with a full 54% being over 50 miles from home [29]. Many of these students find themselves quite far away from their existing friends and family, and rely on **Information and Communications Technologies (ICTs)** to keep in touch.

1.2 Research Questions

My larger research question is “Can remote co-listening support friends/family members in feeling together?” That is, can a particular approach to enabling the co-consumption of media promote an enhanced experience of togetherness with some of the benefits usually associated with being in company of **family** in a way that balances the local and remote needs of the participants? Specific research questions include whether and under what circumstances people will listen together, whether and when co-listening decreases feelings of loneliness, whether and when it increases feelings of well-being, and whether it promotes increased awareness of the other people.

The popularity of social media shows that there is a design space for technologies to support togetherness. The immediate question is whether music could be useful to this effort. The particular opportunity lies in the possibility of creating intermediary forms of connection that are not as demanding or absorbing as overt social media but still offer some of the benefits.

The specific research questions are:

1. Is there a space in young people’s lives for co-listening?
2. How do young people currently imagine the design space between listening and communicating?

3. How do people experience an implementation of a particular approach to the co-consumption of music that balances remote togetherness with their local needs?

1.3 My Approach to Co-listening: balancing local and remote needs of participants

I define “co-listening,” following common denotations of the “co- ” prefix, as “with- ” or “joint- ” or “together- ” listening. That is, a person listening “with” another. We’ve found that in the modern era of many forms of technological mediation, even the word “with” sometimes merits a more specific explanation. Historically, “with” in relation to co-listening would have meant collocated listening or “collective listening” [64].

For the purposes of this work, I define “co-listening” as people who are listening to the same music, synchronously. Co-listening, as I address it, includes the ideas that people are

1. listening to the same music
2. listening at the same time
3. not necessarily in the same place
4. possibly aware of their sharing
5. not required to attend to co-listening in the foreground

My definition supports the possibility that one or all participants of a co-listening session are listening to music “in the background” while they do something else. This definition differs from that of Kirk et al. [54]. Similarly to the friend feature in Spotify, Kirk et al. [54] include asynchronous experience in which a friend may listen to the same music later. They also exclude listening from remote venues in their definition of co-listening [54, p. 56]. For my purposes, “synchronicity” means that if two co-listeners were to connect via another **ICT** (such as picking up the phone or connecting via Skype), they would hear the same music playing at the same relative time. However, there is a limit on what we aim for in talking about synchronicity. We do not aim to support the currently impossible: timing so exact that listeners in remote venues could sing together. Aside from any other issues in implementation, some latency is inherent in remote communication technologies.

There is growing criticism that technology may not be serving our best interests, but is instead being designed to capture our attention [37]. Calls for technology to help us to “act as the selves we wish we were” [113], encourage especially designers to disrupt the individual and capitalistic views of ownership and participation that result in the priority of holding our attention on a single application [106].

I will review the literature on (1) music listening, (2) connection and separation, (3) sharing music, and (4) the social and music listening practices of adolescents, then I will describe the iterative design process of research study followed by CoListen application prototype, and will conclude with a discussion of synthesized findings across three studies and two prototypes.

Chapter 2

Literature Review

No information may be exchanged, but emotions, even simple contentment, may be expressed. And no goals may be pursued or met, but instead mere togetherness may lead to a feeling of warm companionship.

— Rob Strong & Bill Gaver
Feather, Scent, and Shaker: Supporting Simple Intimacy [110, p. 1]

In the past 100 years, the predominant situation of listening to music has moved from one of the public, shared consumption of live production to one of the potentially shared consumption of recorded or broadcast production to private consumption [78]. Small, widely-available, high-capacity devices offer users high-quality, choice[56], and mobility [22, 40]. They also make music personal. Historically, earlier in the era of personal music listening, people found listening to their own music to allay feelings of isolation [22]. Perhaps people have become inured as personal music listening has become the norm, and as personal consumption of media in general has become more prevalent [78]. While personal music listening is now ubiquitous, so too are increased loneliness and unhappiness [82]. Furthermore, the ubiquity of headphones means that even when people listen to music in the presence of others, that experience may be quite private [40, 71]. Sometimes this is desirable, as when people use technology to “cocoon” in public, “escape from one’s current environment through creating a kind of ‘bubble’ in which outside distractions are shut out” [71, p. 278]. However, if indeed “[t]he enjoyment of music is essentially a social experience” [24], then I am curious (as others have been, e.g. [11, 67, 85]) about what benefits there are to more social music listening experiences and whether there are gaps in the design spaces that are currently being addressed.

I will next review the literature on (1) music listening, (2) connection and separation, (3) sharing music, and (4) the social and music listening practices of adolescents.

2.1 Music Listening

“Music is an important cultural resource.... Music is always heard in some social context. It is heard in a particular place and time, with or without other individuals being present, and with other activities taking place... ” [51]

Music-listening is important, ranked by participants among the most important activities they perform, and the most frequently chosen media consumption activity for most situations of everyday life [84]. When Leming [59] asked participants to rate music’s importance, the vast majority of the 58 seventh and eight grade students in his sample rated it as either very important (46%) or somewhat important (47%). Music-listening is popular in the general population, with people ages 18–40 being 44% likely to be listening to music during any 2-hour period from 8:00–22:00 [51], and ages 8–14 spending anywhere from 13 to 17 hours per week [57, 77], or even up to 28 hours (in the case of the sample in Leming [59]) listening to music. This music listening happens primarily in solitude. In a study with 3,500 participants, Rentfrow and Gosling [84] found that the top three scenarios in which a person listens to music were while driving, home alone, or exercising. In an Experience Sampling Method study over fourteen days with 346 participants, North et al. [78, p 76] found that most music listening occurred at home alone. So, music is important to people, people listen to a lot of music, and people mainly listen to music alone.

2.2 Sharing Music

There have been several projects concerned with sharing music. What exactly, with whom, and how they aimed to share all vary widely.

2.2.1 Sharing Files

Some projects explore issues such as managing and sharing music libraries [19, 115]. In the Potato System [33], there were several applications aimed at sharing music files. One example was the *Mobile Music Messenger*, which facilitates song recommendations between users and the re-sale of music files [79]. In Axelsson and Östergren [8]’s SoundPryer, physically proximate cars can stream each other’s music files.

In Jacobsson et al. [45]’s Push!Music, the music files are autonomous and build up a profile, and then move among physically proximate user toward the best matching user. Lenz et al. [63]’s *Mo* is a music player with an integrated speaker [63]. *Mo* could be considered an early prototype of modern “smart speakers”. The important difference between *Mo* and any bluetooth speaker is *Mo* is not only mobile, but it supports a kind of sharing. When multiple *Mos* are proximate, they synchronously play a combination of each device’s synched music

in a random order. Rather than sharing music only with friends or pre-existing contacts or physically proximate others, Kirk et al. [54]’s Pocketsong shared the music one listened to with others who *later* passed through the same physical location where one listened to it [54].

2.2.2 Sharing Metadata

Some projects, instead of focussing on sharing music files themselves, instead share metadata. Like several of the aforementioned projects, Seeburger et al. [91]’s Capital Music also utilizes proximity, but Capital Music shares metadata about played music with geographically proximate others [91]. Reflektor [13] on the other hand, leverages an existing shared experience, text-based chat, with the support of a recommender system, to facilitate the collaborative creation of music playlists (sharing the information about the songs, rather than sharing the song files themselves).

2.2.3 Awareness

Another approach in the literature to sharing music has been the development of systems to support some kind of awareness between multiple people using sound or music as the medium for communication of the awareness information. In order to help visitors to a museum share the visiting experience, Sotto Voce [4] enables museum visitors to hear each other’s electronic guidebook audio. Bach et al. [9] were interested in supporting “spontaneous and opportunistic human behavior”. Their Bubbles system facilitates physically proximate users in developing an awareness for each other’s digital activities and to share music and playlists [9]. Röcker and Etter [85] also wish to develop an awareness among friends. Social Radio can play a friend’s most recent music as a proxy to communicate to the user that friend’s (mapped to a custom-designed piece of hardware) current (or most recent) mood [85].

2.2.4 Co-Listening

In addition to the experiences described above of sharing music files, metadata, or other awareness information, there has been some work in support of co-listening. For this work I define co-listening as the condition wherein multiple parties are listening to (nearly) the same moment of the same music. This definition may not be used by all prior work. Notably, Kirk et al. [54]’s definition of co-listening does not require the synchronized experience I include. Instead, their definition permits people who listen to the same song in the same place, but at different times.

Bassoli, et al. through their projects such as tunA [10, 11], *undersound* [12?], and BluetunA

[14] have explored the meaning of sharing music or listening experiences with colocated others. In the tunA project [10, 11] in particular, they specifically support synchronized co-listening. All of their projects rely on (relatively) short-range connection technology like wi-fi or bluetooth, so the participants of their designed interactions must be relatively proximate to each other, or to a proxy device.

Seeing music as an “...‘eventful experience’, that is, as taking place in real time and space and as involving change and outcome over time” [26], I wanted to support an experience of synchronous co-listening in the current work and prototype. Further, I share the belief, with Bassoli et al. [11], that “listening to the same song in synchrony could better enable people to feel like they are part of a community” [11]. This belief was further justified through Kirk et al. [54]’s discussions of synchrony with their participants.

2.3 Connection and Separation

As technology changes, **Human Computer Interaction (HCI)** and **Computer-Supported Cooperative Work** — a sub-field of HCI under which much of the current work might be categorized — (**CSCW**) have discovered (and keep rediscovering) the human desire and need for connectedness to other people, particularly to people that they care about [87]. The need and desire for connectedness can be through direct contact; it can also be through shared experience, shared meaning, or even shared space. In a review of connectedness, Hassenzahl et al. [39] chose the term “relatedness” as the “label to subsume the diverse terms used throughout the literature, such as connectedness, intimacy, love, belonging, closeness, or togetherness” [39]. Whether there is one underlying psychological construct or many, they all share the idea that the search for connection is a driver of human behavior.

Some believe that our shared experiences have begun to fray [82]; it was not too many years ago that co-workers in the U.S.A. would discuss who was on The Tonight Show last night and repeat a joke from the show that they found funny as a small social marker of community and would help sustain a feeling of modest kinship. In contrast, today’s viral internet videos can be seen anytime on-demand and, at best, are more markers of relationship to sub-groups and cross-cutting communities rather than sustained participation in a larger shared whole. Individual relationships may also suffer. While the need for connection predominates, the more general concept is that people need to regulate the amount of connection they have ([41]). Too much connection can also drive behavior.

However, despite the societal trope of the always-connected, multi-tasking young person, I decided to gather some information about sociality and music listening in a pre-teen and adolescent (aged 9-15) population to gain more purchase on the details of their current practices. This age range is a priori important because they constitute 7% of the American population (21 million of 271 million total [44]), and 11.5% globally [1]. I also selected this group because around this age, people begin to further develop their friendships, to listen to

music, and to increase adoption of technology. Furthermore, in the United States students this age tend to live far apart from their friends, but cannot yet drive, making alternative forms of sharing and connection particularly important.

Adolescents spend a significant amount of time listening to music; as much as 2.45 hours per day [77]. The amount of music listening seems to increase with age (to a point) with 14 year-olds listening 13 hours per week [57], and undergraduate students rating listening to music as highest in everyday importance of all their leisure activities and highest in the share of their leisure time [69]. There are several reasons for this relatively high amount of music listening often related to satisfying emotional and social needs [90, 112]. For example, music listening is related to friend formation [92] through value similarity [16]. One of the top two most important functions of music is “to help me meet people” [89, p. 294]. And, by providing a common ground whereby adolescents can find peers who share their preferences, music listening may give adolescents a sense of being connected to a larger peer network [7].

In a 2012 study of teens’ texting habits, Pew Research found that on average, teens now text 60 times a day [61], up from 50 in 2009 [60]. “More than nine in ten teens (96%) say that they at least occasionally text just to say hello, and more than half (51%) say they do this several times a day” [62, p. 35]. However, this work reported only aggregated summary data about adolescents’ use of a particular technology and communication with peers. In a more extreme example, the Yo app implemented one-bit communication, allowing one person to notify another, with no message content. In summer 2014, Yo became one of the top 5 in Apple’s App Store, and had 500,000 users, who sent over 4 million “notifications” [96]. Yo’s noteworthy adoption further illustrates how we seek relatedness.

These messages appear to serve the purpose of maintaining relatedness. They appear to be meant to communicate an emotional state that is difficult to put into words, and that users might not usually need to express when collocated. Strong and Gaver [110, p. 1] observed, “sociality is often a more subtle and delicate thing” than “relatively explicit communicative acts”. Indeed, as Lottridge et al. [70, p. 2332] found, sometimes we “may not have anything explicit to communicate, they just wanted stimulation from the other to fill the void, a lightweight link to share the mood and feel the other’s presence” [70, p. 2332]. This kind of communication is called *phatic communication*.

“Oh if life were made of moments
Even now and then a bad one—!
But if life were only moments,
Then you’d never know you had one.”
— *Sondheim and Lapine [98]*

Phatic Communication Communicating with each other “just to say hello” [62, p. 35], “[i]nquiries about health, comments on the weather, [or] affirmations of some supremely obvious state of things” [72, p. 313] have been deemed “phatic communion” [72] or later

(and more frequently) “phatic communication” [46]. These kinds of communications are not intended, “...primarily to convey meaning...[, but rather they] fulfil a social function...to establish links of fellowship...” [72, p. 314–315]. Phatic communication is important to building and maintaining interpersonal relationships [20, 58, 65, 72, 93]. Despite its importance in interpersonal relationships, the technological support for phatic communication is lacking. With a decades-long history and booming industry of designing technology to connect people with one another, there has been practically no support for, nor investigation of, this important phenomenon (with only very few counter examples [15, 27, 96]). In addition to investigating supporting phatic communication in modern technology, different such media should be explored since perceptions of our personality seem to vary by medium [111].

There is a parallel between (1) the mundane communications that compose phatic communication and (2) music listening.

“Music is ubiquitous in contemporary life. The prevailing contexts in which we encounter music are, by definition, mundane. They include those contexts in which the most routine activities of life take place: waking up, washing and dressing, eating, cleaning, shopping, traveling. There are, of course, special and ‘out of the ordinary’ events which music can form a part of, even a crucial and defining part, but we would argue that we can only understand these special events and their emotional significance in relation to everyday experience. It is the everyday and normal which frames and helps define the special.” [51]

This need-for-connection phenomenon shows up in many different kinds of social relations. In a survey of remote connection technologies for couples, Branham et al. [18] noted there are myriad ways in which romantic partners might poetically and/or practically connect [18]. Phone companies promote “family” plans that, in part, are sold as means of maintaining connectedness among family members. And, social media has appropriated “friendship” by providing more uniform and widespread means of informal updates that serve a modest connection function.

But human connection is more nuanced: middle school kids will “do homework together,” sitting in the same room with music playing, but one might be doing algebra homework and another doing homework for English. Even if they are working intensely, not talking with one another, their shared space and shared (background) experience provides a sense of togetherness.

Another approach to relatedness is sharing, epitomized by features such as “scrobbling” in last.fm [97] and Spotify [100]. Scrobbling allows users to log the songs they listen to and publicize the log to friends in the local system, or more widely through Facebook or other social media.

Allowing people to broadcast or make known certain data about themselves to members of their social networks or even to the public is very popular. Yet, when we look at this from the perspective of relatedness, it does not seem completely satisfactory. Rather than supporting a give-and-take, bi-directional, or conversational interaction, the technology in most applications defines “share” as simply “send” or “make known to some people other than me.”

Another approach to sharing is the use of Media Spaces. Media Spaces have a long history of facilitating togetherness [38]. Because Media Spaces create a *persistent* channel, they have often been observed to facilitate the sharing of day-to-day life [48, 50, 70], even those Media Spaces that are created ad hoc through user appropriation of **Information and Communications Technologies (ICTs)** [21, 32]. Aside from unremarkable activities of daily life, Media Spaces have facilitated connection between people by supporting concurrent exercise such as in-home aerobics [49] and yoga [74], and even jogging [80]. Media Spaces have shown promising results, but they typically been deployed in fixed locations and have not been designed to be mobile. People have empty moments, “The times when a person is moderately involved in some mundane activity, and wants to feel the presence of or a lightweight exchange with their partner, who may or may not be available for active communication” [70] outside of the home, and may enjoy connecting with their **friends and/or family members (family)** in other settings as well.

While young people are certainly among those who seek connection [16, 34, 35, 92] and have been among those to utilize media spaces to hangout [21], they sometimes experience issues that I would characterize as related to access [21, 34].

Of course various **ICTs** have drawbacks of their own. For example, many teens feel obliged to respond with virtually no delay to text messages [35, 66, 114]. How might we facilitate isolated young people in “keeping in touch” with each other, while mitigating some of the common concerns raised by the usage of modern **ICTs**? **ICTs** are not the only solution that people have tried to use to feel connected. Recently various ostensibly personal technologies such as mobile devices and wearables have been exploited to support the social (e.g. [116]). Some approaches to togetherness are much older and less technological, e.g. the Shakers (a religious sect with as few as 3 remaining members) have long utilized song. With at least 10,000 original songs in their faith, they would, “sing the same song at the same time of day as a way to feel connected across geography” [94, 1:50]. More recently, Leong and Wright [64] studied social practices surrounding music, and found that sharing was a large part of people’s modern music experiences [64]. Indeed for young people as well, music plays an important role in connecting with their peers, socializing, and identity-formation [16, 89, 112].

While clearly feeling connected to or together with others that we care about is important, we try to satisfy this need in myriad ways, with varying directness. From using videochat to (quite explicitly) “call” another and attending to a video call, to ambient awareness technologies that give us some vague notion of the other. While it is common for us to

have the need to connect with others, it is rarely the case that we wish to communicate the same thing to those others, very often having nothing specific to communicate. This desire for togetherness does not mean we never enjoy solitude, but even enjoying solitude can be framed in terms of sociality. “It is a significant feature of many of the everyday musical scenarios that we have outlined that although they may be experienced in solitude, their point of reference is the relationship of the music user to others.” [51]

In an effort to help long distance romantic partners share their mundane daily experience, Lottridge et al. [70] studied what romantic couples wanted to share with each other when at a distance, and how these desires were unfulfilled by existing communication technologies. They developed a concept piece, a technological probe that allowed asymmetrical sharing of either playlists and/or the ambient acoustic environment. They found that couples wanted to share via a simple interaction during “empty moments.” They observe that “one aspect of sharing one’s life with another person is simply to be there” [70, p. 2329].

Strong and Gaver [110] likewise reflect that, “mere togetherness may lead to a feeling of warm companionship” [110]. Feather, Scent, and Shaker, and other works which have come to be called “ambient awareness” technologies offer a simple, ludic interaction that does not attempt to communicate an explicit message, but instead supports that subtle feeling.

Lottridge et al. [70]’s “MissU” system has some similarities to CoListen, but their methodology turns the focus to “empty moments” and then to the ways in which the technology eases partners into and out of shared activities and direct communication [70]. This makes for more of a media-space like application — more of a bringing together — rather than a *being* together.

Long distance romantic couples are not the only relationships that may benefit from designed support for togetherness and phatic communication. **middle schoolers** and **students in higher education** are both highly social, and over-constrained. For different reasons they may be unable to continue their existing practices for building and maintaining relationships.

2.4 The Social and Music Listening Practices of Adolescents

Listening to music is a critical part of identity-formation, relationship-building, and socialization for some young people [7, 16, 89, 92], with ages 8–14 spending anywhere from 13 to 17 hours per week [57, 77] listening to music.

In the prior work, I find several investigations that define multiple dimensions of the social music listening design space. The physical relationship between participants varied from synchronously co-present, through asynchronously co-present, to remote. The music listening varied between synchronous and asynchronous. The context of the individual listeners varied between private and alone, private in public, and public. The interpersonal relationships

between participants varied from selected, co-located friends, to geographically proximate strangers, to remote “friends”, or even public broadcast.

Chapter 3

Study 1: The Diary Study

Prior work shows aggregated summary data about adolescents’ use of technology and communication with peers. I wanted to know more specific information about the daily communication and music consumption practices of pre — and early — adolescents. The results of my study will be used in future work designing for this population to address some of the challenges discussed above and previously [105].

Diary studies — not to be confused with the colloquial use of the term “diary” as a journal in which one writes potentially lengthy, free-form, unprompted reflections — and similar experience-sampling methods have been used often in HCI work (e.g. [25, 78]), and offer the opportunity to gain a rich glimpse into phenomena of interest close to their occurrence. They provide ecologically valid data illuminating on-going practices of the participants [25].

3.1 Study Recruitment

Following a protocol approved by the [Virginia Tech \(VT\) Institutional Review Board \(IRB\)](#), I recruited participants by sending email to all 6000+ graduate students at [VT](#), faculty in our department, word of mouth, and through community outreach coordinators who also utilized Facebook and email. I said that was, “interested in understanding 9–15 year olds, their friendship, communities and whether and how they listen to music.” I added that the participants would be asked to fill out a 5–10 minute questionnaire each day for two weeks, and that they would be compensated.

Parents contacted the researchers to express interest and were asked to complete a recruitment questionnaire about the child’s demographic information (age and gender) and preferred form of daily contact. The recruitment questionnaire included informed consent information (approved by our [IRB](#)). Shortly after receiving the informed consent and recruitment information, the researcher added the participant to the system. Due to the staggered receipt of recruitment information (the first and last interested participants submitted their information a full month apart from each other), the participants were not all participating during the same time. The 14-day span for some participants was at the end of their school year, while for some it began during the end of their school year, and concluded after their school year, while still for others they began and ended their participation in our study during the summer break of their school year. In all, the study ran during May and June of

2015.

After consent, participants started receiving prompts (via SMS or email, according to their preference) to fill out the daily diary questionnaire each evening at 6 pm. Each day's questionnaire started by notifying the child that their parents had consented and that their own assent was signified by completing the questionnaire. At the end of the study the participants were compensated for participation with 20 United States Dollars (USD) whether or not they filled out any daily diaries.

I was able to recruit 19 participants (children, 7 female, 9 male) and from the I have 218 diary responses.

3.2 Diary Collection Method

To facilitate response, I developed and then utilized a small application to prompt the participants via SMS or email (depending on their choice) each evening for 14 straight days [109]. The message reminded the participant of their study identification number and contained a hyperlink to our questionnaire (this link included their participant ID, and in most cases, it was then entered automatically on the questionnaire). To administer the questionnaire, I used a web application, approved by our institutional review board [68].

The questionnaire (see [Study 1: Daily Diary Prompts](#)) had five short, multiple-choice questions. The daily diary prompts participants were asked to respond to every day. The elaborating sub-questions were only asked in the case of affirmative response to the respective primary question.

3.3 Diary Analysis

Twenty-one (21) participants' parents completed the recruitment questionnaire. Two participants never completed a single Daily Diary questionnaire and are therefore excluded from analysis, leaving n=19. Seven (7) participants were reported as female, twelve (12) as male, and none as "other". Thirteen (13) participants preferred to be contacted via SMS, and the remaining six (6) via email. The entire range of ages was represented, with an average age of 12, and a modal age of 10. The overall response rate was 82.0% (218 questionnaires were submitted out of an expected 266). Two participants filled out the Diary on only 7 (half) of the fourteen days, two on only 8 days, but most responded almost every day or every day (see [Figure 3.1](#)). All questions were required, so non-responses were for all questions for that day.

The daily dairy prompts questionnaire (see [Study 1: Daily Diary Prompts](#)) included four yes/no questions. In reporting the responses to these four questions, I calculated the af-

Table 3.1: Every day for 14 days participants in the Diary Study were asked these 5 questions.

Number	Text
1	Have you kept in touch with your friends outside of school today (on the phone, using text messages, through apps, while playing online games together, or anything else)? (Y/N)
1a	How and when did you keep in touch with your friends outside of school?
2	How much did you use text, SnapChat, online games, hangouts or any other technology tool to keep in contact? (Not at all, Occasionally or Frequently)
2a	What did you talk about?
3	Have you listened to music today? (Y/N)
3a	What music did you listen to?
4	Did you listen to any music with friends? (Y/N)
4a	How did you share it?
5	Did your friends recommend any music to you or did you recommend any music to your friends? (Y/N)
5a	How was the recommendation made?

firmative responses as a percentage of the number of diary entries that participant made, where a “diary entry” was a response for the whole questionnaire for 1 day. Next, I will present the results of these four yes/no questions as percentages and then I will present the analysis of the free response questions that followed affirmative responses.

3.3.1 Communication Frequency

As shown in Figure 3.2a, most but not all participants **Keep In Touch (KIT)** with their friends outside of school, but not on a daily basis. Nine participants or 47% communicated with their friends outside of school at least half the time. On the other hand, there were also nine participants who communicated with friends in less than one-third of their recorded responses. However, the median behavior was communication with friends outside of school in only 1 out of 3 reported days.

Evidently, many of the participants communicated with friends in face-to-face after-school forums because, while they reported communicating with friends fairly often, all participants reported not using technology to communicate on at least one day, and 51% of the entries reported that the respondent had not used technology. Only 4 participants reported ever using technology “frequently” as a means to communicate and of these, only one reported using it quite a lot: on 11 of the 13 days on which days she responded.

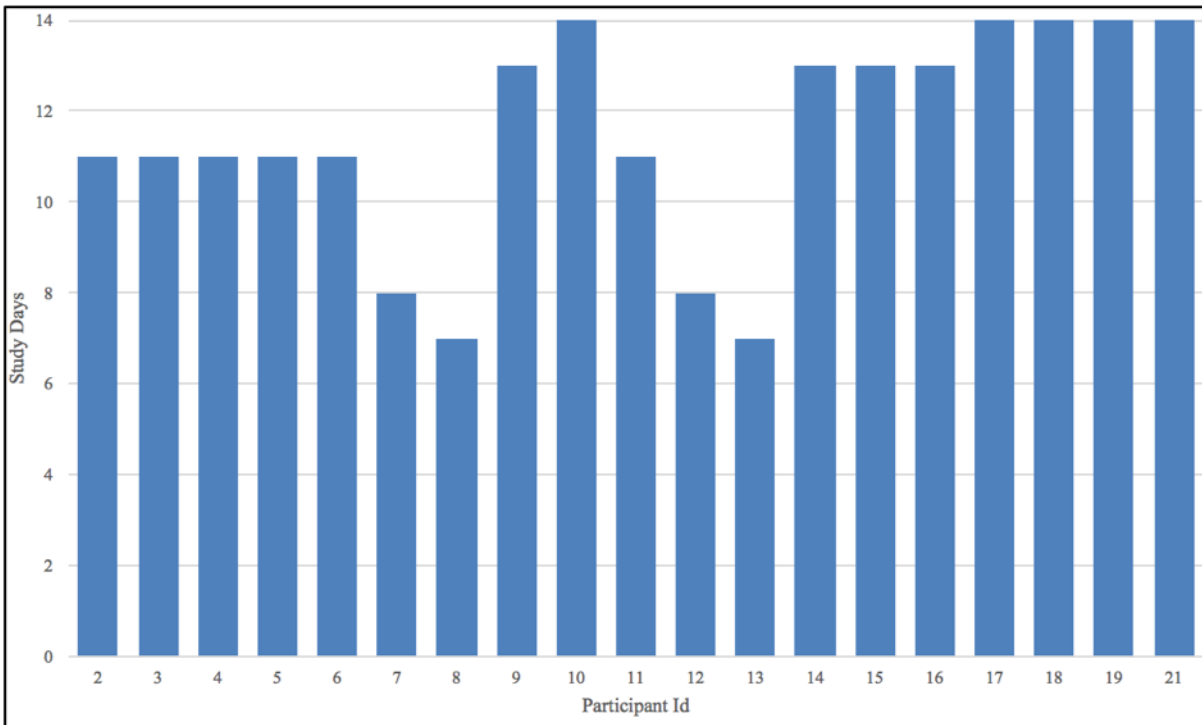


Figure 3.1: Total number of diary responses by participant.

3.3.2 Music Listening, Sharing, and Recommending

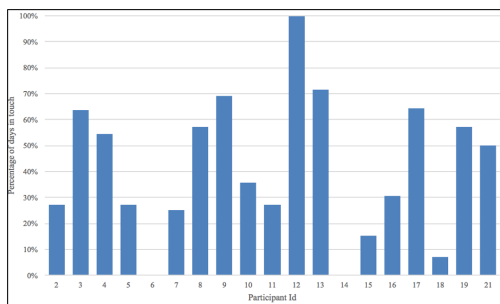
All participants reported listening to music on at least three of the reported days, and 13 reported listening on at least half of the reported days (see [Figure 3.2b](#)).

Ten participants reported listening to music with friends (see [Figure 3.2c](#)). Responses to question [4a](#) (“How did you share it?”) showed that all shared listening occurred in a co-located setting via either speakers or shared headphones. In one case, a participant and friend who were playing a video game together, were listening to the game’s music, and may have been remote (the response was ambiguous).

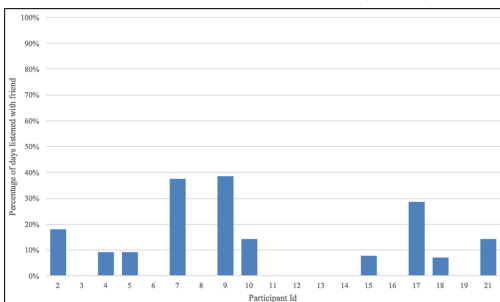
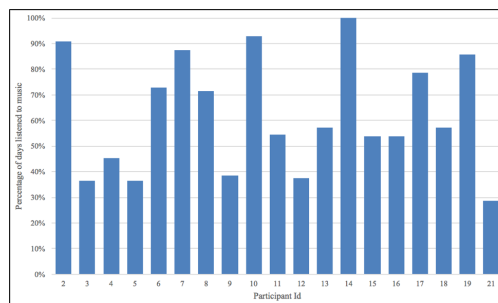
Participants rarely recommended music to their friends (see [Figure 3.2d](#)) and must have done this in face-to-face settings as “music recommendations” did not appear as a response to question [2a](#) (“What did you talk about?”).

3.3.3 Communication Content

Many participants reported communicating with their friends outside of school (see [Figure 3.2a](#)). When these participants were then asked (question [2a](#)), “What did you talk about?” Participants responded with myriad and sundry topics of conversation. From the



(a) Percentage of total days responded that participant indicated they communicated with friends outside of school (KIT). (b) Participants' music-listening frequency.



(c) Participants' music-listening with friends frequency. (d) Participants' frequency of participating in music recommendation.

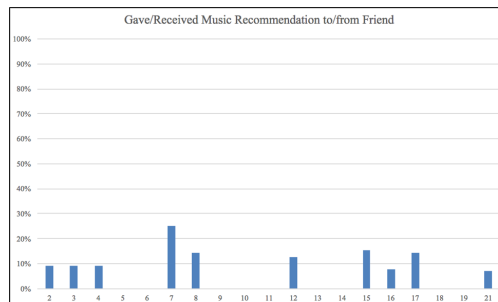


Figure 3.2: Participants' aggregated responses to questions 1,3,4, and 5.

total of 252 diary responses I had, there were 106 responses to question 2a “What did you talk about?”, which elaborated their assertion that they had used text, snapchat, online games, and etc. to communicate with friends that day. My low-inference grouping of answers to 2a yielded 6 categories (comprising 46 codes, see: Study 1: Daily Diary Contents):

1. currently ongoing activity
2. plans
3. shared interest
4. small talk
5. stuff that happened
6. unidirectional

I further grouped shared interest, small talk, stuff that happened, and unidirectional into a super-category: phatic communication. Shared interest and small talk most often categorized what the participants reported talking about. Overall, our participants were almost

Table 3.2: Coding for what participants reported talking about that day of the study.

Category	Frequency	Example Codes
Shared in-terest	35	biking, boys, cooking, extracurricular, photography, tv show
Small talk	31	how doing, miss each other, random, weather, what doing
Stuff that happened	22	day, life, school
Currently ongoing	18	going in game, game, fought, race
Plans	15	get together, plans, party
Uni-directional	4	cell phone, travel

solely engaging in phatic expressions rather than conveying information. Thus our data confirms the frequency of phatic communication found in the Pew study [62, p. 35], further highlighting the importance of supporting friends, “just saying hello”.

3.3.4 Limitations

Diary studies may influence participants to engage in more of certain kinds of behaviors, by keeping them aware of the phenomena [25]; however, the lower level of phenomena I found argues against this having played an important role in the data reported. When solely collecting data from a diary study, as in this work, the ability to follow-up with participants to dive deeper and collect explanations for the data collected by the diary is severely limited. In future work, I will conduct in-person semi-structured interviews with participants to allow us the ability to dig deeper into some of the insights we gained from this work.

Neither our recruitment criteria, our recruitment questionnaire, nor the daily diary questionnaire asked the participants about what **Information and Communications Technologies (ICTs)** are available to them, and what permissions or policies may have affected their usage of them. In future work, I will augment the current data set with information about participants’ access to **ICTs**.

In this work I was interested in adolescents, but other age groups would also be interesting to study with respect to their music listening and social communication practices. For example how **ICTs** [17] and music listening support couples’ relationships.

3.4 Design for Phatic Communication?

The participants in our study reported a low level of communication with friends outside of school with most having no connection 2 out of 3 days. Connection was primarily effected without technology. They did report some technology use in communicating with friends, but surprisingly only about half the time and even then, the majority of their communication was phatic. While they seem to have some interest in keeping in touch with their friends, it is unclear that they have very much to say. Participants in our study did listen to music, but despite its putative role in making and maintaining friendship, they did not listen to music together and rarely discussed it. Although several participants used music streaming services such as iTunes and Spotify, none reported sharing music recommendations via the facilities provided by those (or any other) applications. Neither did they report using more particular features such as Spotify's mechanism for discovering what your friends have listened to sometime in the recent past. Although our study does not resolve the question of why participants fail to use these resources, it suggests that there may be a gap that prevents young people from forming a more shared music listening experience. Further, while they seem to have some interest in keeping in touch, perhaps the explicit, directed nature of current **ICTs** does not provide appropriate support for the more subtle and delicate every day sociality [110]. Such gaps may constitute a design opportunity.

Participants in our study do not report the same amount of technology use for communication with friends or technology use as those reported in the Pew study. This difference may be due to the younger ages of the group I studied, anomalies in the sample, or a systematic bias that arose from our mode of contact. I recruited young people through their parents and may have drawn a higher-than-average socio-economic demographic group by contacting people through the University. It is (slightly) possible that the use of technology to connect is diminishing in some groups. Last, it is possible that the Diary Study method creates more accurate reporting than more general survey methodology, and that the Pew Reports are biased by participant awareness of the social desirability of technology use.

Chapter 4

CoListen v0.1: The First Prototype

CoListen is an attempt to realize a very simple, low-touch interaction. The prototype’s distinguishing feature is supporting a person in listening to the music their “friend” is currently listening to, at approximately the same moment of the same song, and informing that friend that they have been joined in their music listening. After the current song ends, both people will hear the next song in the playlist, if the user-being-listened-to pauses, skips forward, or skips backward, this will all be synchronized to their “listener.”

4.1 Features of CoListen v0.1

When a person using CoListen opens the app to listen to music, they can select from their existing music, but they can also see any of their “friends” who are already listening, and may choose to instead listen to that “friend.” In the current moment of such popularity of mobile music-listening devices, to realistically be used by people in many scenarios of use, CoListen must be mobile.

4.2 The Design of CoListen

In order to probe the design space of co-consuming media and to consider an alternative approach to “connecting” people, I developed CoListen to serve as a media player that intends to “connect” people in a subtle way. It is an attempt to get at the more “delicate and subtle thing”: “sociality”. I designed CoListen in an attempt to communicate no information, “but emotions, even simple contentment, may be expressed. And no goals may be pursued or met, but instead a mere togetherness may lead to a feeling of warm companionship” [110]. Simply: I observed that listening to music, something that has so often been a shared and even uniting experience, has become most frequently an isolating, perhaps dividing one.

There are currently many streaming media players, and even some that support various levels of “scrobbling” (automatic publication of songs a user has listened to) to inform members of a user’s social network about their listening. Additionally, there have been some mobile applications that sought to support users’ interest in sharing music (e.g. Jacobsson et al. [45]). However, there is currently no way for people to co-listen in whatever context of daily

life they find themselves ¹. Many of the current technologies in support of remote people feeling connected is aimed at more explicit forms of communication [39].

From the user’s perspective, the novel component of the app was first apparent as a Friends’ Drawer (see Figure 4.1) that the user can open to reveal a feature to add a CoListen friend, accept or reject (“ignore”) invitations to be a CoListen friend, and cancel a previously made invitation. In CoListen, a “friend” is a CoListen user (identified by their Spotify user name) with whom you might like to be able to co-listen, or whom you might like to be able to co-listen with you.



Figure 4.1: Having clicked on the friends button, the user is viewing their friends who are online in the “Friends Drawer” and sees a Listen button beside their friend “coListen”.

Additionally, a CoListen user can use the Friends’ Drawer to see if any of their CoListen friends are currently playing music and begin listening to the same playlist, at the same track, at the same moment of that track. As the friend’s music progresses so too does their co-listeners’. Usually, this means progressing through a playlist; however, if the friend pauses, skips a song or changes playlists so too will the co-listeners. When user A selects a friend (B) with whom to co-listen, B is notified that A is now listening. If B opens the app, the Now Playing bar will show the current number of coListeners (see Figure 4.2).

Importantly, the app itself provides the users with no facility to invite someone to co-listen with them. I have attempted to design CoListen to attract as little of the user’s attention as possible. They can only be joined while listening, or join a friend who is listening. Once a user has accepted a friend, that friend can co-listen at any time the app is running. (Since

¹The team chat application Discord, which is primarily marketed toward **Personal Computer (PC)** gamers, recently (February 2018) launched a feature in conjunction with Spotify that allows users in the same Discord team to co-listen remotely, but only from Discord’s *desktop* interface.

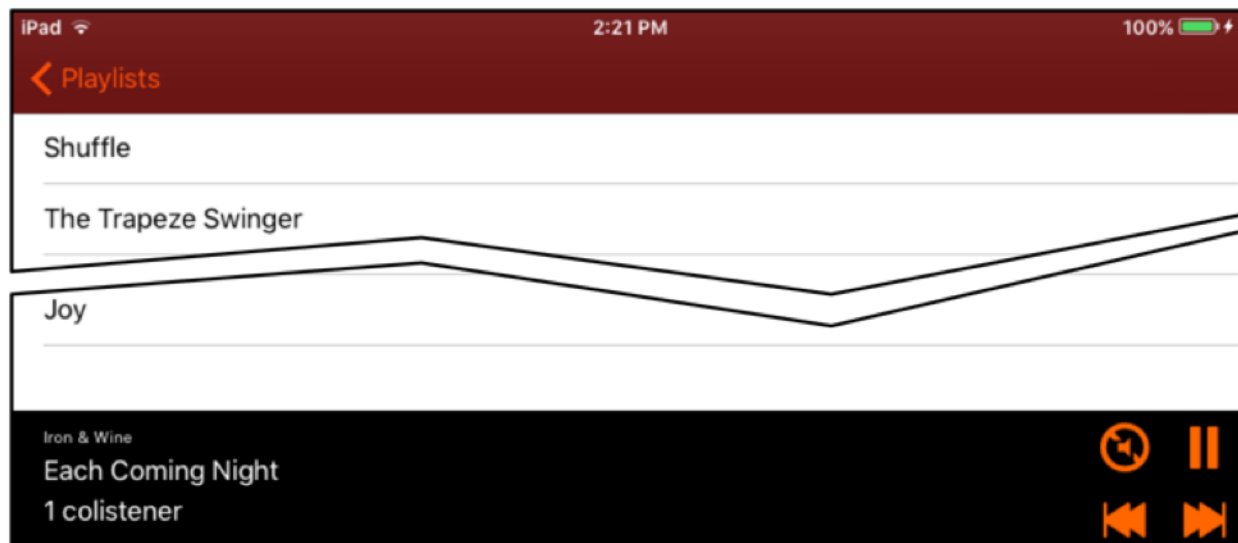


Figure 4.2: Having clicked the Listen button, the user (not pictured) is now listening to the pictured user (who received a notification, and can now see in the Now Playing bar that they have 1 coListener).

the app requires Spotify, a user can always use the Spotify app itself to listen privately.) Only the originating user can pause/resume, skip a track or change playlists. If co-listeners wish to listen to something different, they can, of course, cease co-listening or utilize other existing communications channels (Short Message Service — the technical name for “text messaging” via mobile telephone —) (SMS), for example) to make an explicit request.

Listening to music, even with friends, is often not a foreground activity [51, 76]. My conjecture is that by making the design of co-listening lightweight and low-interruption, CoListen can facilitate participants’ feelings of relatedness in a way that balances this remote need with their local needs. Yet, people may legitimately want to have certain controls. Shklovski et al. [95] found that Information and Communications Technologies (ICTs) may benefit from utilizing certain strategies for maintaining dialectic tensions. CoListen is designed to support *segregation* [95] (or fragmentation [52]) by implementing its own “friend” system so that people can choose explicitly with whom they might want to co-listen. CoListen is designed to support *selection* [95] by requiring people use CoListen specifically rather than the Spotify app directly. I attempted to design further support of *selection* [95] through requiring people who wish to music in CoListen to first add that music to a Spotify playlist via the Spotify app (not within CoListen, which also meant I needed to implement fewer of Spotify’s pre-existing features). My design aims to find the sweet spot between these goals of (1) facilitating participants’ feelings of togetherness and maintenance of their remote interpersonal relationships and (2) their local interpersonal relationships and privacy needs.

4.3 The Implementation of CoListen

My system relies on a developer **Application Programming Interface (API)** from an existing, commercial, streaming music service. The app connects to this service and uses it underneath for all media player functionality. Then the app communicates many of the user interactions to a custom server via a Websocket channel. When the server receives information from a user that is relevant to others, it rebroadcasts it to them. For example, if Alice is listening to one of her playlists, and then her friends Bob and Charley join in to co-listen, when Alice's playlist advances to the next song, her app will notify the server, which will in turn notify Bob and Charley so that they can continue to co-listen in sync with Alice.

Because of the relative lack of availability of streaming music **APIs**, CoListen had to be implemented as a native mobile app for either Android **Operating System (OS)** or **iOS**, and had to utilize the Spotify **Software Development Kit (SDK)**. Due to my personal device running iOS and previous grants in the Virginia Tech Center for Human Computer Interaction purchasing a large number of iPads, I chose to build the app initially in **iOS** (but would like to have a parallel version on Android in the future). As such, CoListen consists of an **iOS** app and a server application to support the app.

The server is necessary only as an intermediary to facilitate inter-device (and inter-user) communication. As a convenience, I also do all logging on the server so that I do not have to collect logs from individual users' devices for my research data. The server also implements a small component of the Spotify authentication protocol, but this will probably not be required in the future as the Spotify **SDK** (and associated authentication flow) matures.

To implement this shared environment and associated interactions (see **Figure 4.3**), I leveraged an open source wrapper of Spotify's developer API, libspotify to build a smartphone app. Our server application (running on an Amazon EC2 micro instance [3] running Amazon's Linux distribution [2]) is written on the NodeJS platform [43]. The client is also built primarily in Javascript by using a cross-platform framework called Cordova [5]. To better structure this client-side javascript, I used the AngularJS framework [31]. To facilitate communication between client and server, I used Socket.IO [23]. To interact with Spotify's API, I used CocoaLibSpotify [101].

4.3.1 Limitations

At this time, CoListen does not re-implement all features of a streaming music player. That is, since it currently requires a Spotify account, I did not re-implement all of Spotify's features. CoListen users can see their list of Spotify playlists (**Figure 4.4a**) and they can see the tracks that compose each list **Figure 4.4b**. They can also play these playlists as they are, shuffled, or beginning from a specific track. For the prototype phase, CoListen users must create their playlists via Spotify's web, mobile, or desktop applications.

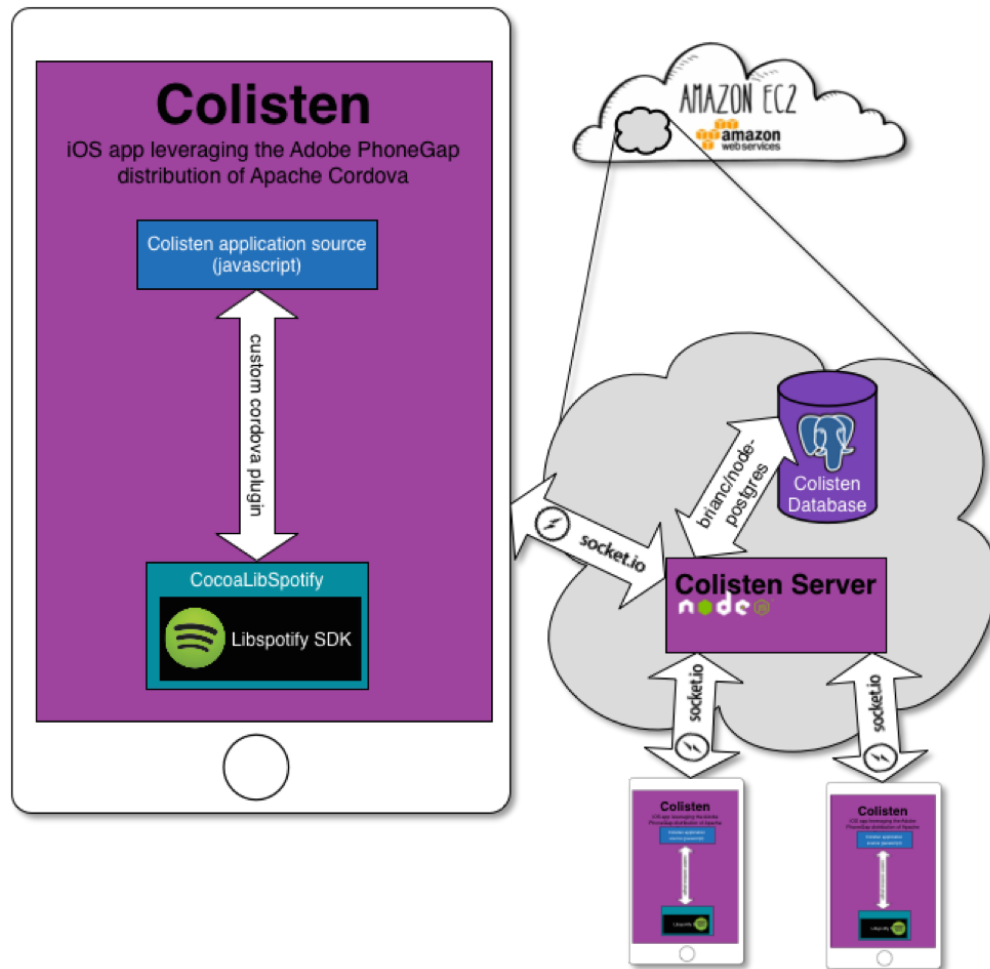
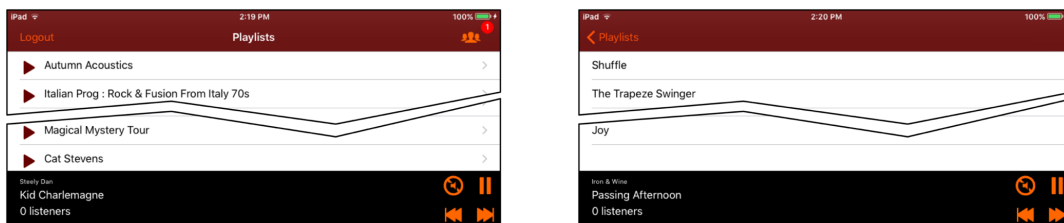


Figure 4.3: CoListen v0.1 comprises a NodeJS server and a “native” cross-platform mobile app built on Apache’s Cordova.

The Spotify SDK requires that users of third-party applications (like CoListen) sign in to a paid (premium or family) Spotify account. For the current work, I have created several Spotify premium accounts.



(a) CoListen showing the playlists in the logged in Spotify user's library. (b) CoListen showing the tracks in the logged in Spotify user's selected playlist.

Figure 4.4: The CoListen prototype does not re-implement all features of a streaming music player. These figures show the playlists listing and track listing screens.

Chapter 5

Study 2: CoListen in the Lab

“It’s more of like a social thing, rather than, I want to listen to music. Or like, I wanna hang out with my friend, listen to music, whatever that song may be.”

— Participant 15127L

To find out more about what semi-rural young people’s thoughts, wishes and preferences, I conducted a study that recruited pairs of young people to come in together and engage in a semi-structured interview, a design charrette, and user-testing. Following Druin [28]’s framework for children’s roles in research, I employed the child as informant method [88].

5.1 Participants and Recruitment

Following a protocol approved by our [Institutional Review Board \(IRB\)](#), I recruited participants by sending emails to 6000+ graduate students at [Virginia Tech \(VT\)](#) and faculty in our department, word of mouth, and community outreach coordinators who used Facebook and email. Our recruitment text targeted 9–15 year-old children and advertised our interest about them “feeling connected with each other.” Further, I explained that participating children must bring a friend (also aged 9–15) and try out an app to listen to music together and talk about their schoolwork and social lives. I asked the participants to come with a friend to this study for three reasons:

1. I hoped that having their friend with them for the interview, they would feel less intimidated by the process and more comfortable with sharing.
2. In the design charrette, I thought that having the two participants each design something and then be present for each other’s explanations, would prompt them to ask each other questions either during the presentation or even during the designing itself.

3. By having two friends together as participants, the scenario for trying the CoListen prototype and co-listening with a friend was closer to our planned deployment in future work.

Parents contacted the researchers to express their child’s interest and were asked to complete a recruitment questionnaire about the child’s demographic information (age and gender) and the name of a friend with whom their child will participate. The recruitment questionnaire included informed consent information. Shortly after receiving the informed consent and recruitment information, the researcher contacted the consenting adults to arrange their respective children’s session.

On day of their session, the participants arrived at our building and once both members of the pair had arrived, I obtained their informed assent (having already obtained their parents’ consent). In one session, I had a quartet rather than a pair, as three of the participants were triplets and the fourth was friends with all three. Participants were compensated for participation with 20 **United States Dollars (USD)**. Twenty-six child participants were included in the study. The children’s gender was reported as female (12), male (14), or other (0). Their ages varied within our (9–15) recruitment range with an average of 11.5 years, and a standard deviation of 1.8 years (modal ages of 10 and 13, none were 14). Twenty-two participants reported that they have siblings (one of them has 9 siblings).

5.2 Interviews

The semi-structured interview guide started by replicating the questions in our previous extended, 2-week long diary study (see **Study 1: The Diary Study**) about young people’s access to devices, music-listening, and communication. The entries in the diary study had been very short, and I wanted an opportunity to ask for elaborations on such responses from this group.

The interview guide also contained further questions and topics to help deepen our understanding of participants’ contexts. Additionally, as the sessions progressed, some exposed new topics that the interviewer appended to the interview guide for future sessions.

5.3 Design charrette

The design charrette employed the participant as a design informant to design a co-listening technology. After the semi-structured interview, I asked participants to “design a technology that would let you listen to music with your friend, while you are each in your own homes.” I gave each participant blank U.S. letter-size paper to begin with and put out a cup of markers and pens. The participants were told that they could use as much paper as they needed,

and asked to inform us (I remained in the room) when they were done. Once all of the participants in the session finished their design, I asked them to explain their designs.

5.4 Prototype testing

Next, I asked participants to try our own prototype of such a technology. I handed an iPad to each participant (in the one session that involved four people, two participants shared each of the two iPads). I demonstrated how the app worked, and asked if they had any questions. Next the participants used CoListen to browse playlists and listen to music while sitting together. Part of this was listening to the same music on the two different devices at the same time. Finally, I asked participants for their feedback and questions. In this discussion, I often asked participants about their thoughts about the ways that CoListen was similar to or different from their design. From the three parts of the study, I collected different kinds of data, so I analyzed them in different ways.

5.5 Data and Analysis

The length of our study sessions ranged from 26–44 minutes (average of 35:10 with a standard deviation of 6:16). The study sessions occurred between October 2015 and April 2016.

5.5.1 Interviews

I analyzed the data in two phases. In the first phase, I started with our interview guide and numbered the topics to produce the beginning of our transcription guide. I then began transcribing the interviews, simultaneously coding for those topics. As I encountered new topics, I added those to our transcription guide, and reviewed completed transcripts to ensure they considered the additional codes. Also, the transcriber (in most cases the interviewer) wrote memos into the transcripts to surface and record interesting observations. From these transcriptions I produced counts for several questions that elicited nominal data, and sought quotes that represent the data. In the second phase, I coded the transcripts, especially the portions that included the discussion of participants' designs and of the CoListen test. The focus of this coding process was the interaction of co-listening from how such an experience would be initiated to the composition of the co-listening group

5.5.1.1 Keeping in Touch

Like the prior work, I found that most of my participants kept in touch with their friends outside of school (16). Three participants said they do not listen to music, one clarified that

they do “sometimes.”

From the responses of twenty (20) of our participants, I know that they use myriad methods to keep in touch with each other: face-to-face, call, text (i.e. SMS), Instagram, Skype, voice chat in a (console) video game, FaceTime, Snapchat, Facebook, Twitter, email, and Google Hangouts (video); with one participant using (the maximum we saw) 5 of these. Unsurprisingly, texting was the most popular medium that my participants used to keep in touch with their friends outside of school (10 participants use texting, 5 of whom “mostly text”). Perhaps surprisingly, the next most popular medium was voice calling (on a phone) with 5 participants reporting utilizing this method. Three of the five who use voice calls indicated only email (1) or no other form of communication (2) with their friends outside of school.

I learned that my participants contact each other after school, in the evenings and on weekends, but not normally before school. The content of their talk was often characterized as “nothing”, “anything”, “what they were doing” or other communications that can be characterized as phatic, that is, language used for general purposes of communication rather than to convey information; however, as in the prior study, it also included plans [107].

The amount of “keeping in touch” varied widely, with some being so busy with extracurricular after-school activities (e.g. gymnastics) and others not having their own devices that they reported keeping in touch less than once a month. While other participants reported keeping in touch with their friends once a month, one to two times per week, four to five times per day, and all the time, “Probably when I get home, I have it in my pocket, all the time, have my ringer turned all the way up, and usually I’m [also] on Xbox.”

5.5.1.2 Listening to Music

Twenty-three of my participants reported listening to music, three reported that they did not. They report listening to a variety of music: “pop,” “heavy metal,” “not rap,” “rap,” “christian,” “variety,” “Sam Smith,” “Kidz Bop,” “country,” “Hideaway,” “Fetty Wop,” “Drake,” “Flo Rida,” “Bieber”.

My participants listen to music via several different sources (see Table 5.1). Perhaps surprisingly, the most popular music source for our participants was FM radio (24 participants listen to it). I also found it surprising that YouTube was such a popular music source (the second-most in my study with 14 participants using it for music), but apparently, participants fit a larger trend in this respect as during our study, YouTube released a new app, YouTube Music. Ten of my participants reported listening via Pandora.

Table 5.1: My participants reported listening to music from a variety of sources. Notably FM Radio remains high in this population and YouTube ranks higher than other methods designed specifically for listening.

Music Source	Frequency
FM Radio	24
YouTube	14
Pandora	10
iTunes	6
Spotify	4
Google Music	2
SoundCloud	1

5.5.1.3 Co-listening

I found that more of my participants listened to music with their friends or family than was found in our prior work [107]. In my study, 21 reported doing so, while one reported “not usually”, and one said they did not. My participants used a few different methods to listen with others, most popularly their mobile devices’ speakers (12), automobile’s stereo (11), or their home stereo (10). Only 2 participants reported sharing headphones (one earbud for each person), and only one participant reported listening to music with friends or family via their computer speakers. I asked some of these participants who co-listened with their friends or family if they listen to the same music when they are co-listening as when they listen alone. Eight said they listen to the same music, and four said they listen to different music (2 of these because their parents would be selecting the music whenever they are co-listening, i.e. in the car), but one said because sometimes he listened to music to which he thought his parents may object.

5.5.1.4 Music Recommendation

The participants reported engaging in music recommendation with their friends or family more often than found in our earlier study [107]. Fourteen indicated they participate in music recommendation, and five that they did not. None of these recommendations were made utilizing any explicit technological support or feature. The majority of these recommendations were made in a face-to-face setting (10), and only 3 reported sharing recommendations via text message.

Table 5.2: Participants reported having a variety of communication and entertainment technologies.

Technology	Frequency
Television	17
Video game console	17
	— 9 (XBox)
	— 8 (PlayStation)
Computer	10
iPhone	6
iPad	4
FM Radio	2
Tablet	2
Nintendo 3DS	2
Kindle	1

5.5.1.5 Access

In an attempt to fill some gaps in [The Diary Study](#) [107] and to develop a more comprehensive understanding of the situation for these young people. I also asked questions that help understand participants’ access to technology.

I asked some participants whether they had their own device to [Keep In Touch \(KIT\)](#), and learned that 10 do and 5 do not. Of those who do, five had iPhones, two have a cellphone, and one person each has an iPad, slide phone, tablet, or no such device.

Aside from those devices that are their own, I asked what technology was available in their homes for communication and entertainment. Televisions, computers, video game consoles and iPhones were the most frequent (see [Table 5.2](#)).

With all this technology available to these young people in their homes, another issue of access is parental policies about their usage. Of 24 responses, nine indicated that they were required to finish homework and/or chores before they could use some of these devices for leisure, five said there were no rules, five said there was no specific rule, but if their parent came to feel that the young person had been using a device for a long time, they would tell them to get off. Other kinds of policies that our a few participants reported were: just to ask their parent before using such devices, only using them at a certain time of day (e.g. not in the morning when the family is trying to go to school/work), usage permission based on grades at school, or having a fixed amount of time that they were allowed to use the devices. One participant declined to tell us their parents’ rules, telling us that the rule is, “kinda private.”

I sought further understanding of the young people’s music-listening practice by asking about how they discover new music and whether their family had any rules about what music they

may listen to. From fourteen respondents to the music discovery question, I saw that FM radio was the most-used source of discovery (9), face to face recommendations (7) were the 2nd-most frequent. Less frequent music discovery options included Pandora, YouTube, CDs, Vine, and Facebook. Few of my participants indicated that their parents had rules about what they could listen to. Eleven said their parents had no rules, 3 had to ask first, 2 just have to make sure not to purchase the explicit version of any track, and one participant had unspecified rules where their parent may just not like a song and tell them not to listen to it.

5.5.2 Design Charrette

The participants' design charrettes varied in length from 3.5 – 15.2 minutes (avg. 6:13, with standard deviation of 3:15). The participants' designs, and the ways they were represented were fairly diverse. Some participants made a list of statements or features, many drew their design and added some text for explanation, and some tried to indicate successive steps in their design that were required to establish a co-listening session. Variation along five dimensions emerged from the design gallery analysis: Initiation, Group Composition, Control, Hardware, and Activity Prioritization.

5.5.2.1 Co-listening Initiation

One issue, how a co-listening session was initiated was illustrated in several (13) of the designs. From these designs I characterize the ways to initiate co-listening as a spectrum (see [Figure 5.1](#)).



Figure 5.1: Participants' designs depicted a range of co-listening initiation. At one extreme the listener can just listen to a friend, while at the other extreme, a friend can just start playing music that will be heard by another.

For simplicity, I have labeled the 2 participants of a co-listening session as the listener and

the broadcaster to describe who is playing the music and who is listening. Note: in cases toward the center of the spectrum, these labels seem less appropriate. For this dimension, I observed that in some designs, one user (in this case the “listener”) could see what their friend is listening to, and just listen to them (while participants did not know it at this time, this is how CoListen functions), in other cases this user had to request permission to listen (Figure 5.2).

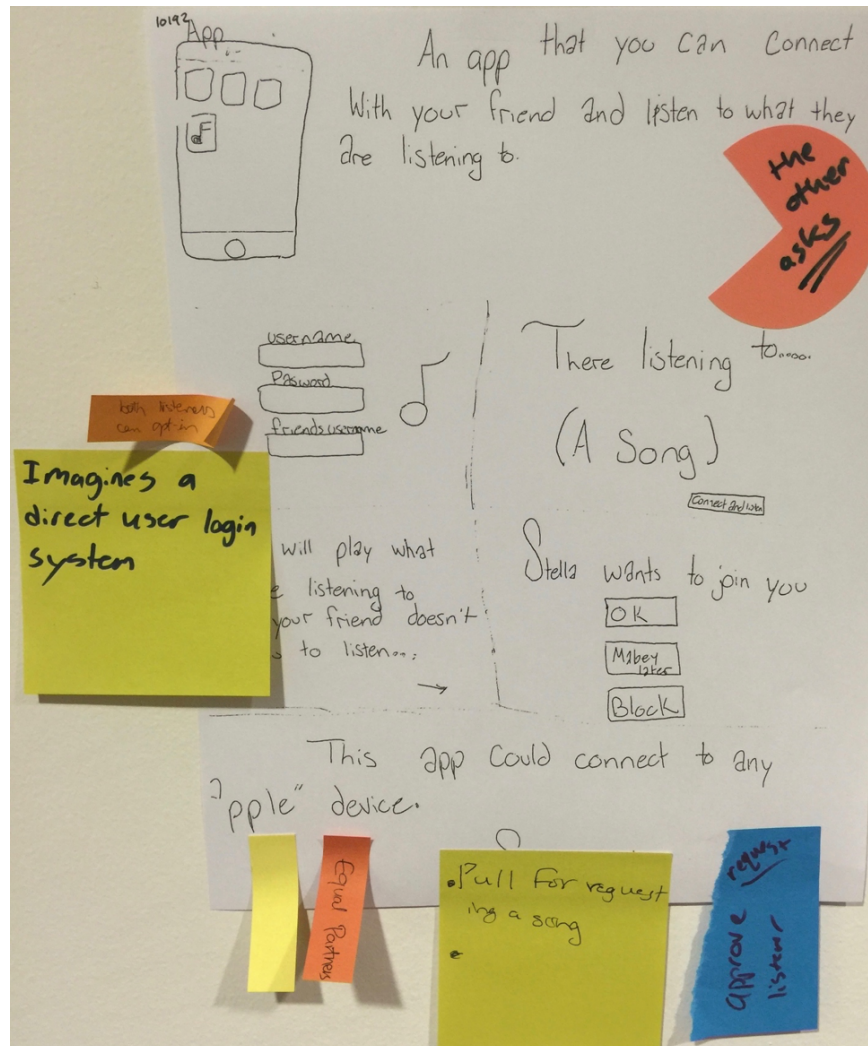


Figure 5.2: Depicts a user interface for requesting to co-listen and for accepting or rejecting such a request.

In still other cases, a user could either “tune-in” (Figure 5.4) to their friend or “invite” their friend. At the other extreme of the spectrum, a user could only invite a friend to listen with them (e.g. “An app that allows you to have friends and when you want to listen to music with somebody, you could send them a Request showing the song who its by and they will have the option to Accept or Decline” Figure 5.3), or in other cases, could just play

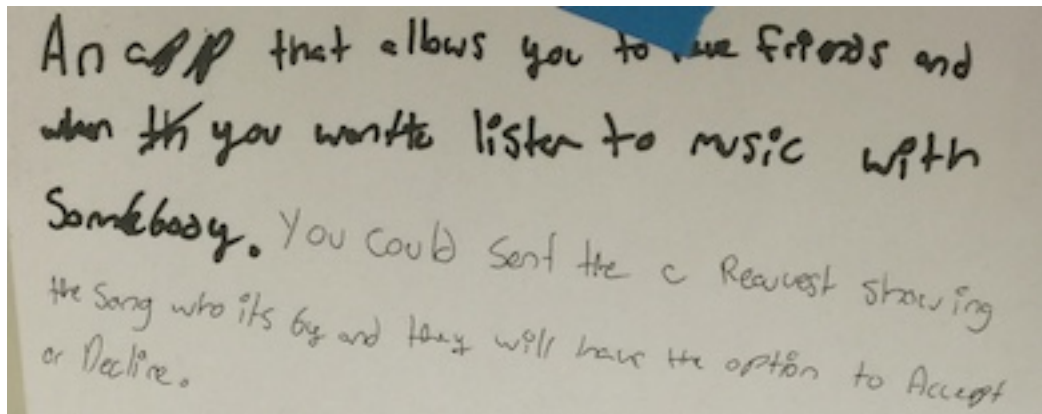


Figure 5.3: Participant suggests an invitation method for initiating co-listening.

something that would also play for the friend.

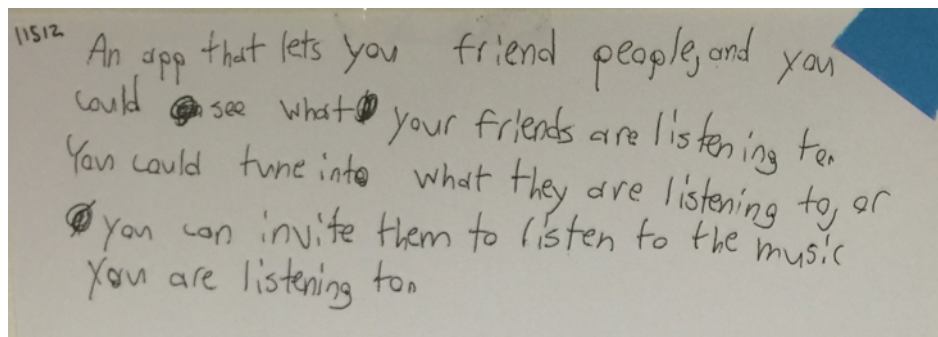


Figure 5.4: One way participants imagine initiating co-listening is by just tuning in.



Figure 5.5: Co-listening group compositions in participants' designs.

5.5.2.2 Group Composition

While the framing of the activity focused on dyadic co-listening, participants' designs supported different co-listening group structures (Figure 5.5). In the case of a Fixed Dyad (e.g. Figure 5.6), the participant's design illustrated that the dyad who could listen with each other was embedded in the system:

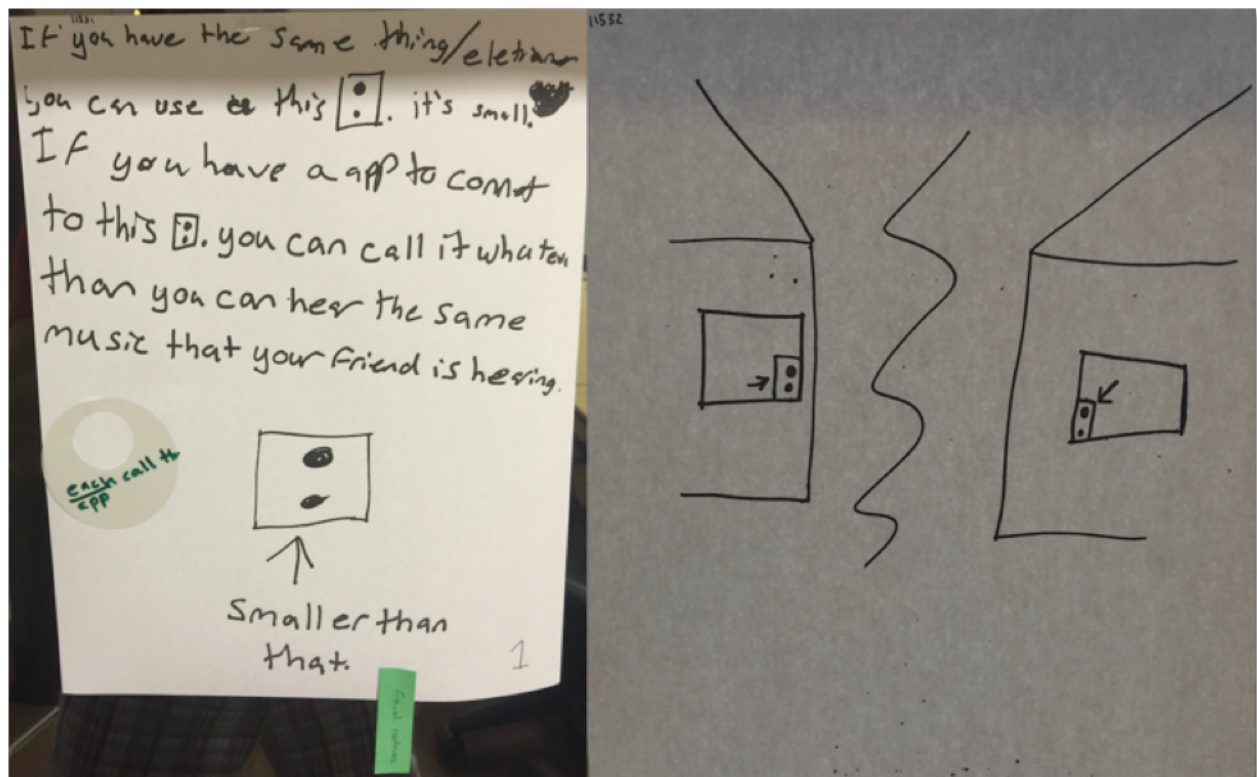


Figure 5.6: One participant designed a new piece of hardware that could sit between a user's music player and their headphones in order to send the music coming in not only along its way to the headphone wire, but also wirelessly to another such device to which a friend would be listening.

1. "there's a specific product for this, it's not really like an iPhone, but it's like a music player... it's already connected to another one, so you can buy it like, it's like a ... friendship thing, and they're like, automatically connected to each other".
2. "if you have this thing, and if you have an app to connect with it, you can hear the same music that your friend is hearing"

In other cases, the group was still constrained to a dyad, but who might be the members was configurable (Figure 5.7), while at the other extreme found in our participants' designs, a group larger than a dyad could co-listen, and the membership of this group was configurable (again, participants did not know this at the time, but this is how co-listening functions in our prototype) as in one design that employed "5 headphone spaces" and that in Figure 5.8.

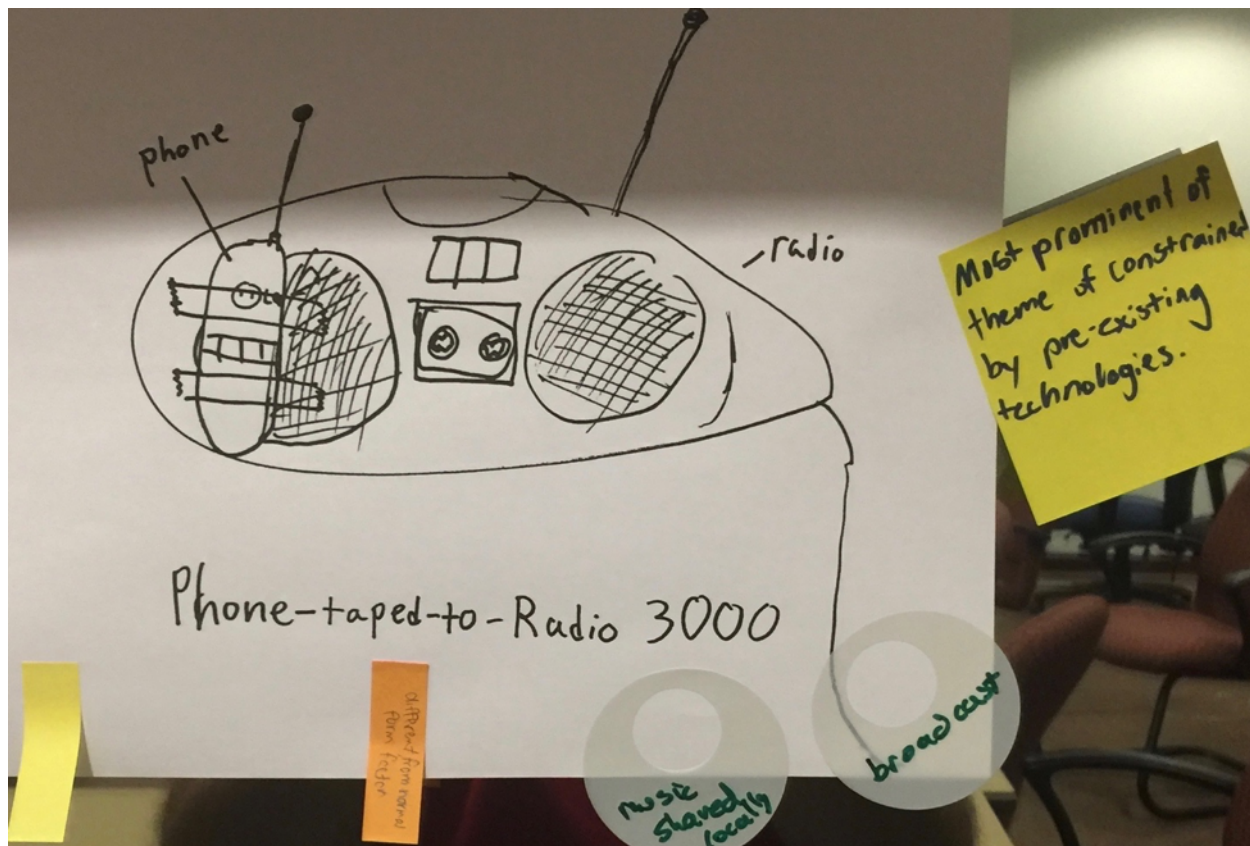


Figure 5.7: A participant's design for a technology that would support remote co-listening.

5.5.2.3 Control

Some participants addressed issues of control in their designs. Certainly, some examples of this are included in [Co-listening Initiation](#), but our participants also surfaced other control issues. As part of initiation, some designs enabled an invited or a requested partner to deny, ignore, or block the requester ([Figure 5.3](#)). Deciding what tracks would be played was implicit in some designs (e.g. a design that was [not suited to remote co-listening] just a smartphone which would have 5 headphone ports). While other designs more explicitly explored track selection (e.g. [Figure 5.8](#) indicates that the user is “not [the] song picker”). Some of these designs, implied the existence of a third-party arbiter that would be necessary to support their control features.

5.5.2.4 Hardware

Some participants seemed more constrained by, or at least more interested in existing technologies' hardware from older devices such as a boombox to touchscreen mobile devices (cf.

CoListen). Some added a new hardware component to an otherwise existing/familiar technology, and some created entirely novel hardware (see [Figure 5.9](#)). I observed that their designs reference a wide range of form factor from boomboxes to more modern touch-screen mobile devices. Some of their proposals were attempts to implement co-listening using existing technologies in combination “you tape a phone, to a speaker of a radio, and you turn on the radio, and you turn the music on low so it won’t bust the person’s eardrum” ([Figure 5.7](#)).

Others imagined wholly new hardware (see [Figure 5.6](#)), perhaps as additions to existing hardware, such as a set of wireless earbuds that a user would have surgery to have implanted next to their eardrum, which would wireless communicate to an iPod as well as to another set of these owned by a friend. Many of the participants designed their co-listening technology as a new app that would run on an existing mobile device ([Figure 5.10](#)), while others imagined adding only a new feature to an existing app ([Figure 5.11](#)).

5.5.2.5 Activity Prioritization

It seems that all of our participants’ designs were developed in one of two ways (see [Figure 5.12](#)): (1) started from either a social technology (e.g. [Information and Communications Technologies \(ICTs\)](#)) and added a music-listening feature, or (2) that they began with a music-listening technology and added (social) support for co-listening (e.g. [Figure 5.7](#) and [Figure 5.8](#)), which is more similar to CoListen’s design.

5.5.2.6 Access

In some of my participants’ designs I saw evidence of their concerns about device availability and connectivity that would affect their access to a co-listening technology. In some cases, (e.g. “5 headphone spaces”) there was an attempt to reduce the number of devices necessary below 1:1. In other cases the concern seems to focus more on connectivity (e.g. “...not have to use data or wifi...”). These concerns echo Grinter et al. [35]’s discussion of the home economics of media (in their case, [Short Message Service — the technical name for “text messaging” via mobile telephone —](#) (SMS) and [Instant Messaging \(IM\)](#)), but with a different larger of technologies.

As young as 9 years old, my participants were cognizant of the costs associated with their technology usage, especially when listening to music. Several of my participants who mentioned listening to music via YouTube indicated that it was because they could do so for free. Others of my participants discussed the importance of songs being cached on their mobile device because they had little or no bandwidth available when away from wifi.

5.5.3 CoListen Testing

We briefly explained our prototype to the participants and then invited them to use it for a while. Participants used the app on average for 6 minutes (standard deviation of 3:30). Many participants enjoyed the music they chose to play in CoListen, and began to bob their heads. When the participants clicked the “Listen” button on their co-participant, they often smiled when their device began playing the same track at the same time position.

Participants tested listening to different tracks and playlists and shuffling the playlists. They tried pausing/resuming and skipping tracks. They tried listening with each other 19 participants said they would use CoListen. They reported their interest in using CoListen in a variety of circumstances: whenever not doing homework (4), while not in the car (i.e. at home where they have wifi, 4), weekends (1), and during carpooling (1). One participant who said that he doesn’t usually listen to music said that he would like to use CoListen because with it, “you can see what mood your friend is in, sometimes you’re in a mood for... see what your friend is doing”.

From our discussions with participants about the differences between their designs and CoListen’s implementation, we learned that 3 participants prefer to initiate co-listening as it is implemented in CoListen (listener just listens), 9 prefer to receive a request from their friends before that friend gets to listen. One participant said that (unlike the CoListen implementation) they, “would like to be able to listen to people who aren’t my friends because they might have different taste and interesting music.” For some participants, I was able to continue our discussion in more detail, thinking through various scenarios of CoListen use. In these cases, the young people did not seem to think it be would be weird for them if their friend were listening to them, and that friend had a friend of their own listening to them.

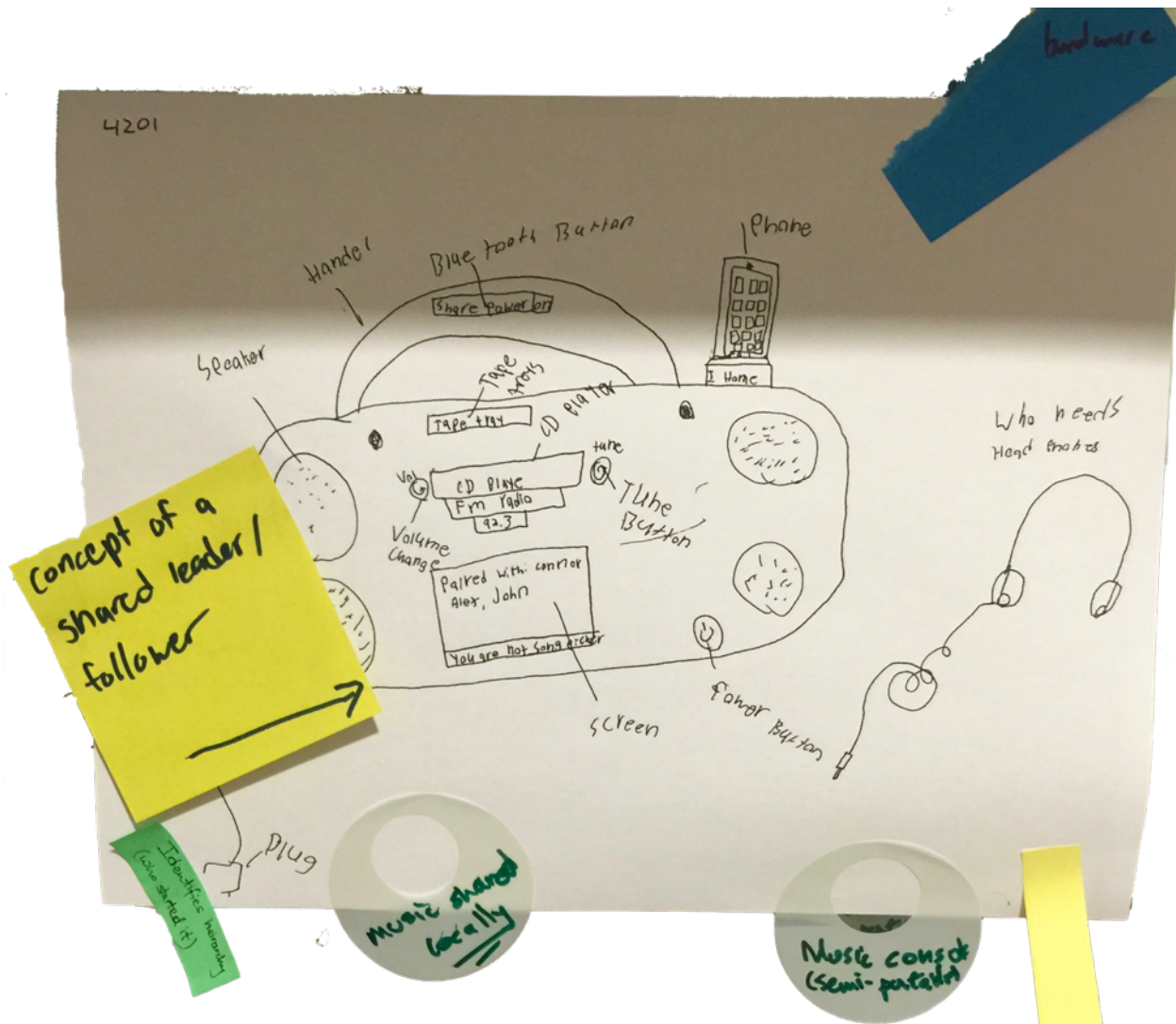


Figure 5.8: Participant's design depicts a boombox that supports various music sources (cassette, cd, FM radio), and has a display to indicate with whom the user is co-listening, and that the current user is "not song picker".



Figure 5.9: Co-listening hardware novelty in participants' designs.

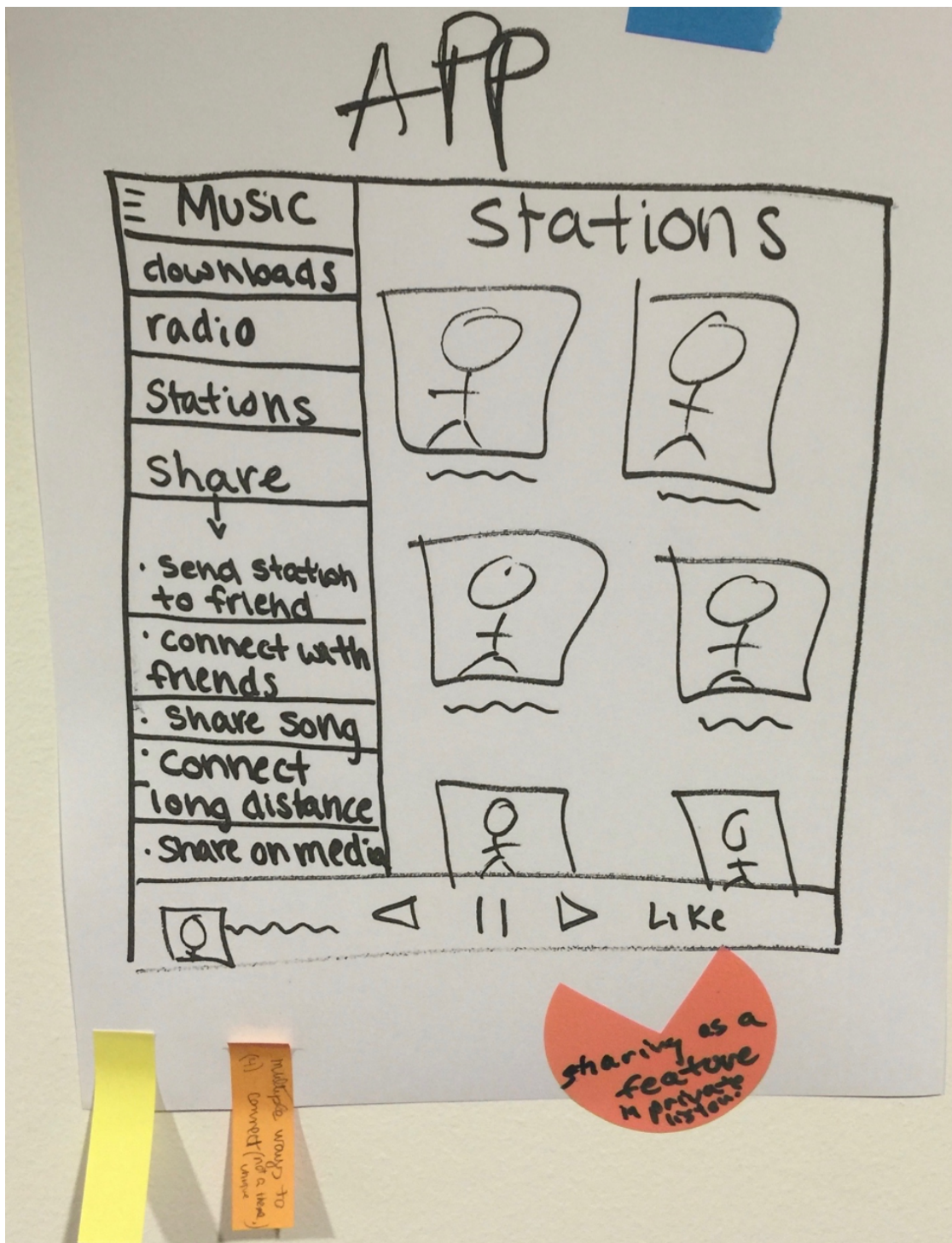


Figure 5.10: Co-listening hardware novelty in participants' designs.

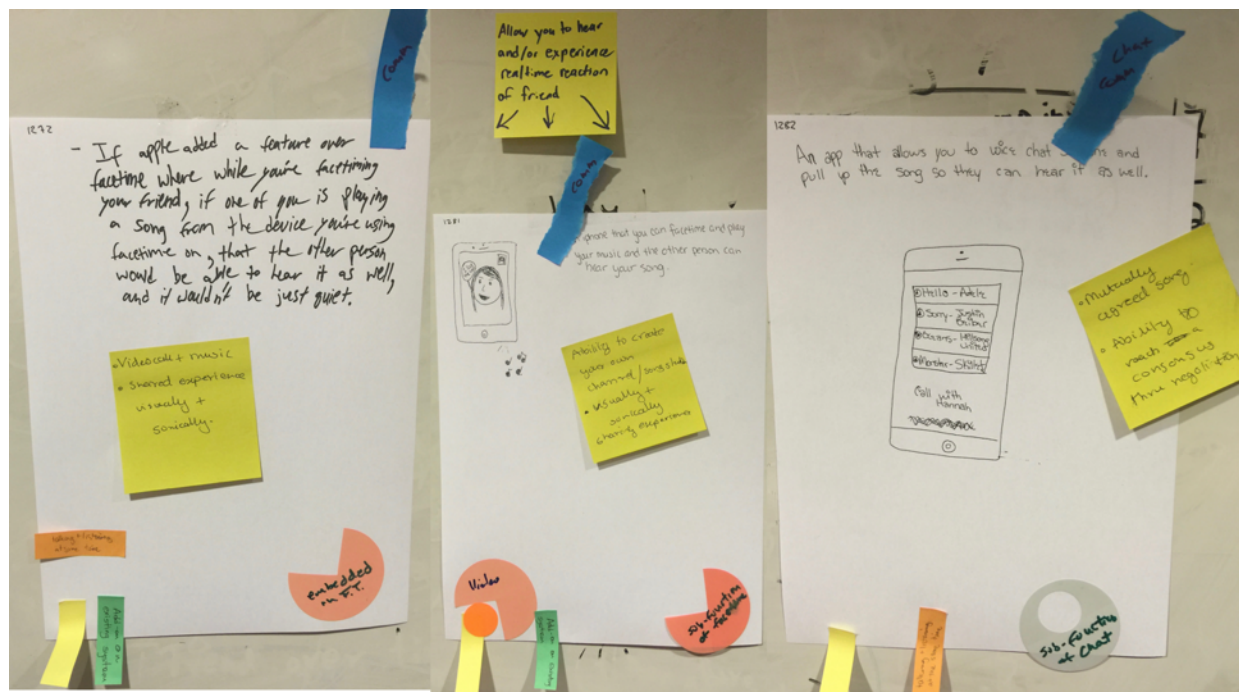


Figure 5.11: Three participants all designed co-listening as integrated with voice/video chat on their mobile devices.

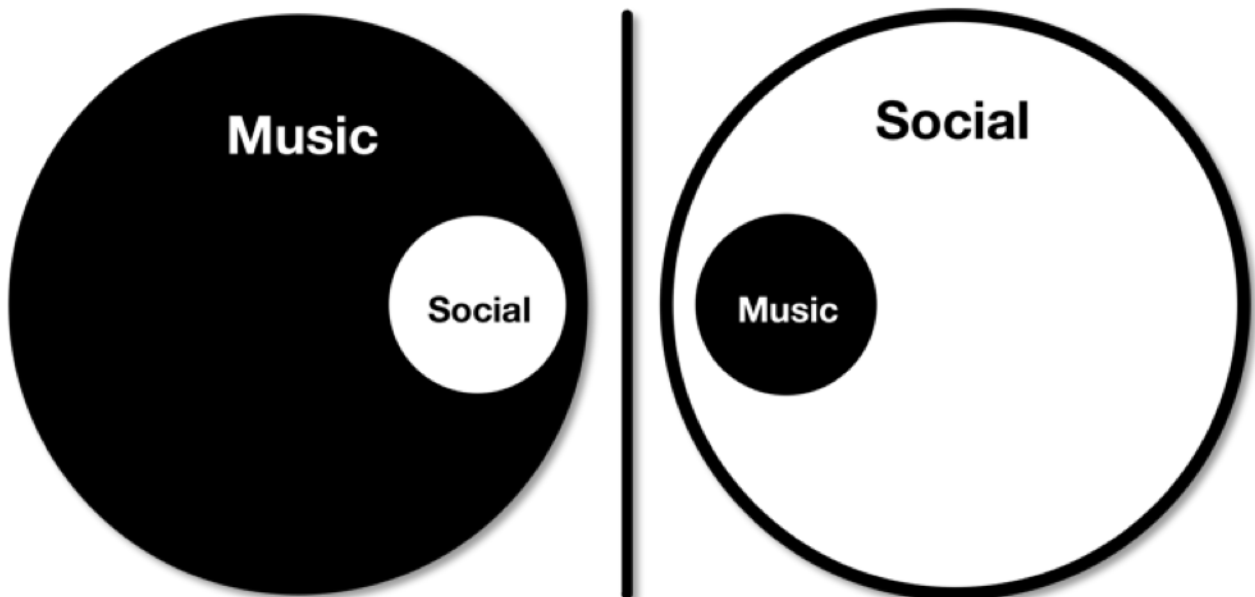


Figure 5.12: Participants' designs could be categorized as (left) adding sociality to music-listening, or (right) adding music-listening to social technology.

Chapter 6

CoListen v1.0

After some preliminary work (see [CoListen v1.0](#)), the cross-platform solutions were deemed too immature for the purposes of CoListen (no community, no support, no error logs). In the summer of 2014 when I began to build the native [iOS](#) client, Apple had begun their shift from Objective-C to the new Swift programming language. Knowing how Apple does not always support legacy systems as well as developers might like, I decided to use the new Swift language. Apple also began to move away from their previous [Graphical User Interface \(GUI\)](#) for building [GUIs](#) — Interface Builder — to a newer component of their XCode [Integrated Development Environment \(IDE\)](#): Storyboards. Another big change at this time was that Spotify went from primarily supporting 3rd-party streaming apps through a C library (CocoaLibSpotify [101]) to offering an Objective-C-based Spotify [iOS Software Development Kit \(SDK\)](#)[99] (usable in Swift through implementation of a “Bridging Header” [6]). The result of the change in platform and supporting library was a from-scratch rewrite of the app (actually the third). Finally, it was clear that to investigate the kind of co-listening initiation I was interested in, I needed to be able to ask for the CoListen state of a user apropos of nothing they’ve done, but rather in response to actions from their friends. To have the ability to rouse the CoListen app without local user interaction, it is necessary to use the [Apple Push Notification Service \(APNS\)](#).

The primary goals of the redesign were to:

1. Use native iOS platform (rather than immature cross-platform solutions)
2. Support background notifications
3. Utilize the new (rather than deprecated) interface to Spotify

In addition to changing these underlying technologies, through the [Interviews](#), [Design Charrette](#), [Prototype Testing](#), and dog-fooding, I learned of a few changes that I thought would improve CoListen. Some examples are:

1. Add a link to quickly take a CoListen user to the Spotify app
2. Allow refreshing the music library on demand
3. Show thumbnails for playlists

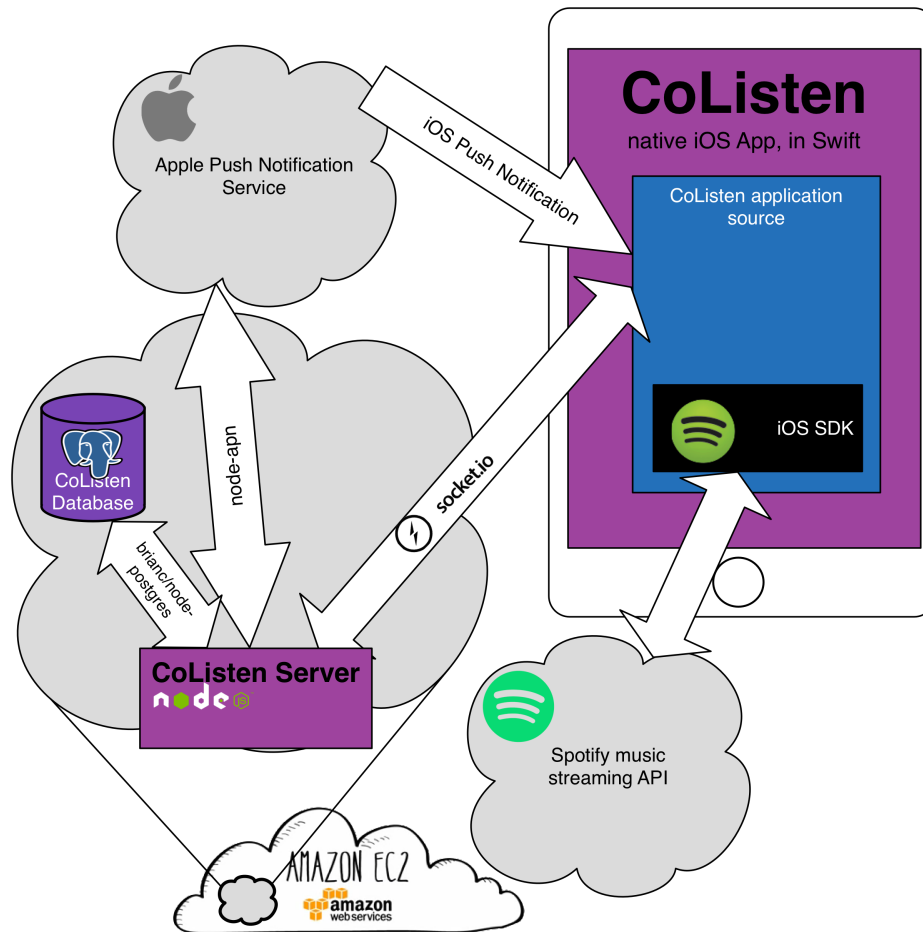


Figure 6.1: The CoListen system comprises a native iOS app as the client and a NodeJS application as the server.

4. Show friend images
5. Allow for role-reversal
6. Play audio in-app for limited notifications
7. Change the target of interaction when initiating co-listening
8. Display indication of whether our friend is currently choosing the music they are listening to or whether they are listening to someone else

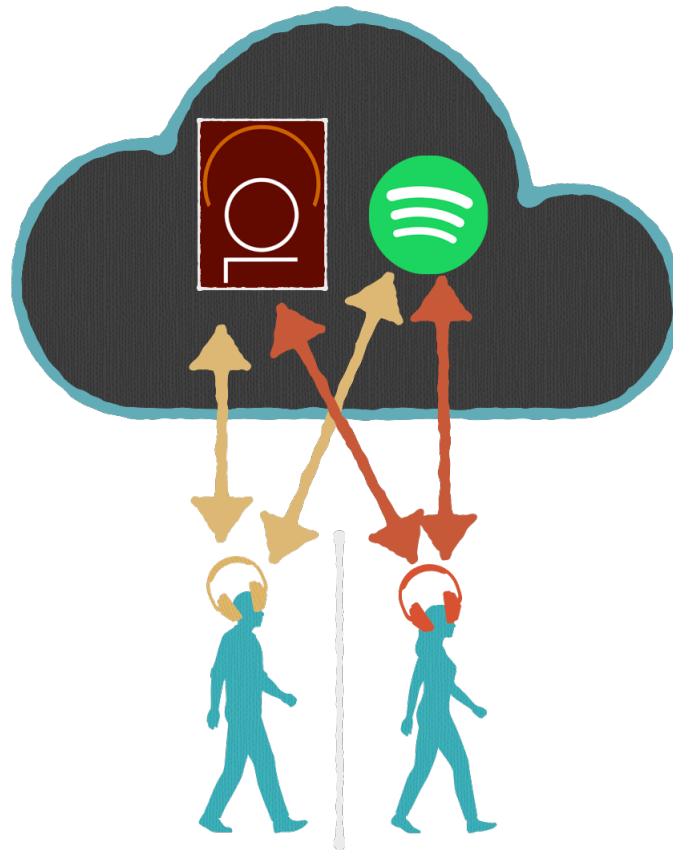


Figure 6.2: The participant’s device must maintain a relatively stable connection with the CoListen server and with the Spotify server.

6.1 System Development

While the first prototype was complex and difficult to debug because of the early stages of PhoneGap development that resulted in poor documentation, complex tool chains, and a lack of a developer community, moving to native iOS development, particularly doing so while adding the aforementioned features would prove challenging. First, Apple was pushing hard for their new programming language Swift to overtake development in Objective-C. Next in order to develop on an Apple platform the Swift programming language is actually a rather low hurdle. In addition to learning the new programming language, one must build their code in XCode on a Mac. While I was using a Mac laptop at the time, undergraduate students whom I recruited to assist in developing the app often did not have a Mac.

The CoListen System was developed as research-grade (rather than production-grade) software. In balancing the concerns of a production-ready app with the limited time and resources available for this project, I aimed to develop a prototype that I could test quickly. In following this agile approach, I can learn early about interactions and features that may

or may not succeed, and devote resources accordingly. Unfortunately, in order to implement certain features (such as **Push Notifications**), I did not have complete freedom of choice (e.g. I must use **APNS** for Push Notifications). So while my system was targeting research-grade, the requirement to utilize certain third party services (Push Notifications, Spotify’s music streaming **Application Programming Interface (API)**, and Apple’s “ad hoc” deployment process) was at odds with the research-grade software quality target. Because these third party services aim to support apps in production deployments, they require levels of security, validation, and other best practices that are important indeed in a business-critical production deployment, but that are overkill, and costly for a prototype. Thus the recruiting additional (student) developers to work on the CoListen system requires a larger investment than is typical for agile development projects. The simplest system architecture that can support the interaction as design comprises a server to facilitate communication between CoListen users (including passing notifications through the **APNS**) and a client to stream the music and provide the user interface (see **Figure 6.1**).

6.1.1 Push Notifications

Push Notifications were one of the primary additions for this version. In order to rouse an app on **iOS** without the user prompting the app to get scheduled, one must utilize Push Notifications. Apple provides the **APNS** to send notifications to **iOS** devices, and further they require that their service be utilized in order to send push notifications. Push Notifications were initially intended to send a notification to an **iOS** device that has an app installed which has registered the device for notifications. One of the earliest uses was to enable email clients to receive new email messages without having to poll the mail server. This original use resulted in a notification that the user would experience (visually, aurally, and/or haptically). Later Apple developed so-called “silent push notifications”. The intended use of such notifications initially was to allow an app to do a little bit of processing in response to a notification so that the app’s state would already be updated whenever the user returned to an app (rather than seeing some stale state that is jarringly refreshed shortly after the app entered the foreground). The possibility of sending “silent push notifications” would enable CoListen to selectively use regular (“noisy”) push notifications or “silent push notifications” depending on whether the user should be interrupted.

Unfortunately, the **iOS** Simulator that Apple provides for **iOS** developers is not an eligible recipient of Push Notifications. Thus, in order to test Push Notifications a developer must have a actual (rather than simulated) **iOS** device, and hence for multiple people to collaborate on development, they would each need an **iOS** device. In order to deploy development code to an **iOS** device rather than to the simulator, a developer must have an Apple Developer account. This not only costs \$100/year, but requires that all developers who will test on an **iOS** device have such an account or share the username and password for a single Apple Developer account. Needless to say this is a barrier to recruiting developers to the project.

In addition to testing being expensive in hardware and developer memberships, it was expensive in time. With the introduction of silent push notifications, Apple implemented a quota to prevent degraded user experience. When an app reaches its quota, push notifications will not be delivered to the app for an unknown period of time. That is, if an app can get scheduled to run without any indication to the user that it has been doing so, and if it does so too often, it would deplete the device's battery charge, and the user would not know why, and may develop a negative opinion of the device. Interestingly (perhaps to prevent side-stepping of their quota), the developer's app is not notified, and cannot find out when their app has reached its quota.

6.1.2 Spotify Streaming

Spotify was (and is at the time of writing) *the only music streaming service that provides a third party API*¹. To use an app (like CoListen v1.0) that uses the Spotify iOS SDK, the app's user must be a Spotify Premium subscriber (\$9.99/month). The Spotify iOS SDK manages its own connection to Spotify's servers for music streaming. So in addition to the CoListen iOS app maintaining a connection with the CoListen server, the app (though Spotify iOS SDK's internal code) must also maintain a connection to Spotify (see Figure 6.2). Besides maintaining communication and state with these separate servers, another result of using the Spotify iOS SDK is that the third party app developer (me) must rely on the SDK's API for managing and querying the state of the music streaming.

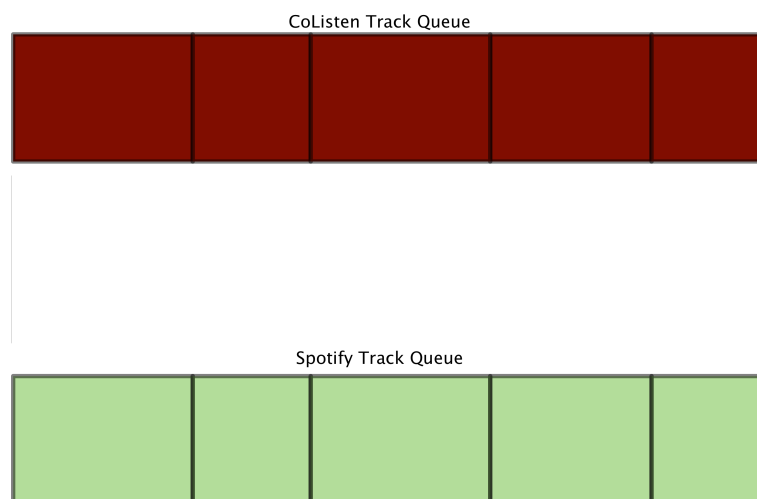


Figure 6.3: The developer ought to simply mirror in their own queue data structure the actions performed on the queue via the Spotify iOS SDK.

¹Of course I could have developed the music streaming myself, but then the complexity of this project would have ballooned even further.

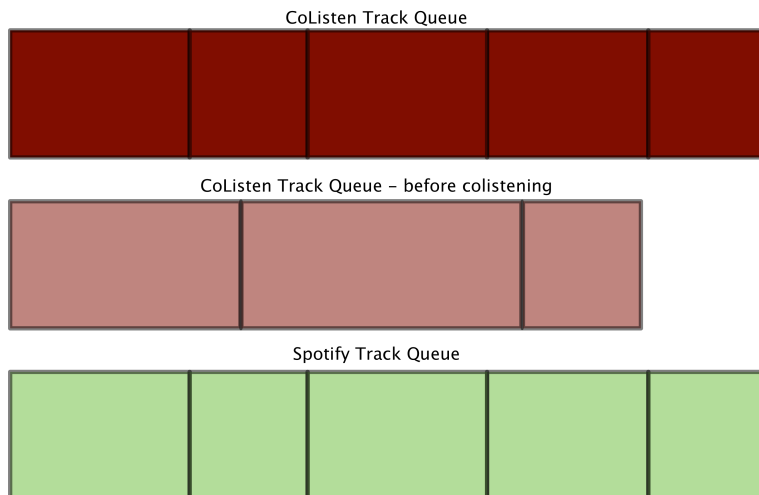


Figure 6.4: The developer ought to simply mirror in their own queue data structure the actions performed on the queue via the Spotify **iOS SDK**. The third queue enables resume.

The **SDK** does not provide the developer access to its internal queue. A developer can enqueue music, or replace the music on the queue, but the developer must keep their own copy of the queue. Obviously the developer should make changes to their copy of the queue whenever modifying the Spotify **iOS SDK**'s queue as in [Figure 6.3](#). In the case of CoListen, I have one other queue (as in [Figure 6.4](#)) which I use to track the user's queue prior to listening with a friend (whose queue would replace theirs). This way, should the friend a user is listening to become unavailable, CoListen can resume playing the user's previous music. Unfortunately, it turns out that due to connectivity issues, bugs, or perhaps due simply to undocumented limitations, I have have observed that the **API** calls are not always reliable, and so the queues can become out of sync as in [Figure 6.5](#).

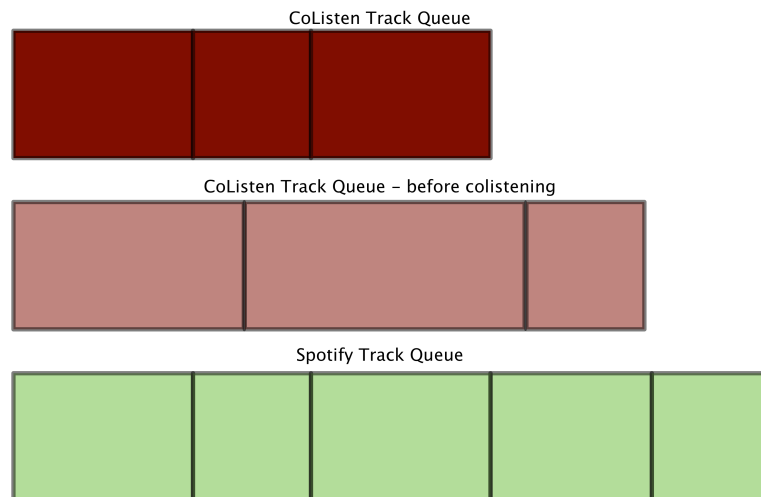


Figure 6.5: For various reasons, the developer cannot be certain that their **API** calls have produced the expected queue state.

Chapter 7

Study 3: CoListen in the Wild

“Music is a great way to bring people together just in general, so an app that literally physically brings people together is pretty cool.”

— Participant 7, *Study 3: CoListen in the Wild*

Having run two studies that addressed: **RQ1** whether there’s a space in young people’s lives for co-listening and **RQ2** how they think about listening to music and connecting with each other via music-listening, I developed another iteration of the CoListen prototype (**CoListen v1.0**) that the participants used in **CoListen in the Lab**. For the CoListen in the Wild study, I had three main interests:

1. Do people actually use the CoListen app? Why?
2. Do people like the music-listening experiences they have using the CoListen app? If so, what do they like about it?
3. Do people like using the app as a means of connecting and feeling together with their friends and family? Why? How?

In order to further determine **RQ1** whether there’s a space in young people’s lives for co-listening, and **RQ2** how they think about listening to music and connecting with each other via music-listening, and **RQ3** to learn about how people experience co-listening, I deployed the app in the wild. I hypothesized that people:

1. Would enjoy co-listening with their friends or family
 - 1.1. To answer this, I asked them directly and I looked at how often they used the app.
2. Would feel some degree of “togetherness” with the person with whom they are co-listening

- 2.1. I asked them directly including utilizing the Inclusion of Other in the Self scale.
3. Would feel less lonely than when they were not co-listening.
 - 3.1. I asked directly.

7.1 Procedure

In short, the procedure was to have people join the study with at least 3 friends and to use the app whenever they like for two weeks in the context of their daily life. The system reminded them if they did not use the app for 48 hours and prompted them at the end of each day to respond to a brief series of prompts about their experiences. By asking participants to use the app for two weeks, with people with whom they had pre-existing relationships, I intended to explore the meaning of co-listening in the context of participants' daily lives and interpersonal relationships.

7.1.1 Recruitment

The study had a relatively long and open enrollment period, utilizing “snowball recruitment” in order to recruit participants who had existing social ties. To find the initial participants, I utilized our list of previous participants (who had expressed interest in our future studies) as well as mailing lists at Virginia Tech, and fliers in local coffee shops, grocery stores and similar in the Blacksburg area.

7.1.1.1 Selection Criteria

1. At least 11 years old
2. Already have an iOS device
3. Can identify at least 3 contacts (each also meeting the previous criteria) who will also join the study

7.1.1.2 Onboarding Process

Participants first completed the **Current Music and Communication Practices** to express their interest in participating, verify their eligibility, provide their contact information, and to share their demographic information and information about their current practices for keeping in touch with friends and family and listening to music. The latter questions about their communications and music-listening practices were based off of those questions used

in previous studies (see [Study 1: The Diary Study — Daily Diary Questions](#) and [Study 2: CoListen in the Lab — Semi-structured Interview Questions](#)).

After at least 3 eligible people listed by the eligible participant agreed to participate in the study (and each of those people had also at least 3 eligible friends or family who are participating), I contacted those participants to ask them to complete the further questionnaires including [Affective Benefits and Costs of Communications Technologies \(ABCCT\)](#)s for both [SMS](#) and [the participant’s most-used ICT that is not SMS](#).

Once the participants complete the Enrollment Questionnaires, I contacted them to add their iOS device(s) to the CoListen study.

Once the participants in the circle (minimum 3) have all added their devices, I contacted them to install the CoListen app and give them their Spotify gift card code for 1 month of Spotify Premium (necessary to use third-party apps, like CoListen, that rely on the Spotify [Software Development Kit \(SDK\)](#) [99]). I also explained to them that they can begin using the app.

7.1.2 The Trial

Having recruited their friends and/or family members to join them, and having all completed the enrollment process ([participants](#) were ready to begin the trial. I asked participants to use CoListen as their primary means for listening to music during the 14 days of their trial. If, during the two weeks of their participation, a participant did not use CoListen for 48 hours, they received a text message (see [104]): “Hey, I noticed that you have not used CoListen for three days. Is everything working ok?”. The CoListen app logged (on our server) the participants’ interaction with the app in order to support the app’s functionality and also for purposes of data analysis in service of my research. In addition to data automatically collected by CoListen, I utilized the diary method [25] to ask participants to complete [short questionnaires](#) at the end of each day of the study. It was difficult to guarantee that participants would all begin using CoListen on the same day. While I waited until all of the group members completed the enrollment process before proceeding with providing the app to the group, not all group members installed the app and began using it on the same day. Where possible I prevented the daily diary prompts from triggering for participants whose other group members had not yet begun using the app. However, this was a manual process and difficult to coordinate. Therefore participants within a group did not always respond to daily diaries on the same fourteen days (see [Figure 7.1](#)).

7.1.3 Post-trial

At the conclusion of the study, I asked participants to complete [an ABCCT questionnaire for CoListen](#). I also asked them to share their thoughts about CoListen via [questionnaire](#)

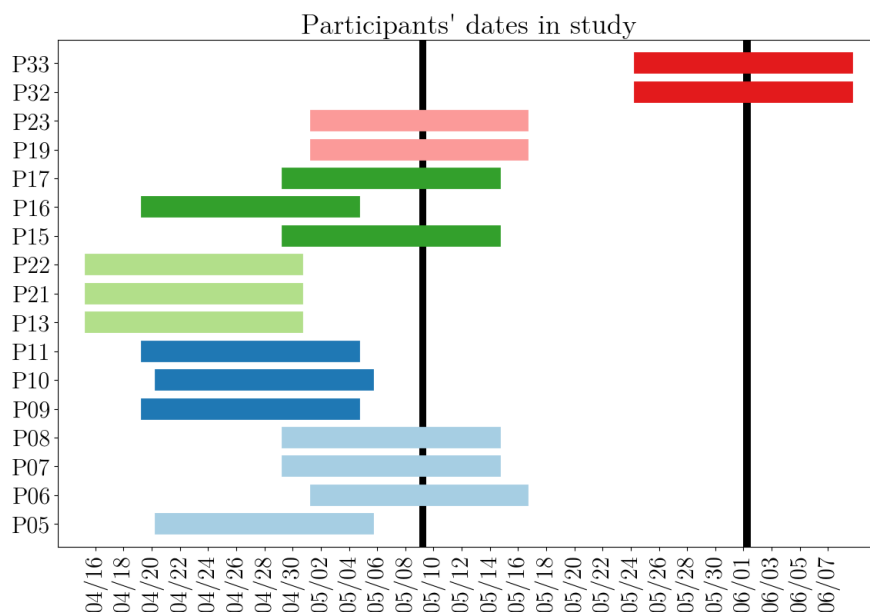


Figure 7.1: The participants' fourteen days of the trial. On May 9, I was able to correct some notifications that were not previously reliable. On June 1 I corrected an issue where one particular notification was not clearly alerting the user.

and follow-up [semi-structured interview](#).

7.2 Data and Analysis

I recruited 34 participants of whom 21 actually completed the pre-trial procedure and were eligible to begin the trial. Because not all the participants completed the pre-trial procedure, my trial groups sizes varied more widely than I planned ([Figure 7.3](#)).

One group of participants comprised two committee members (Deborah and Steve) and some of their family members. In an interest to limit their sway over especially qualitative reporting, I have not used quotes from this group as exemplars in the following analysis. Overall this group actually experienced more breakdowns with the system than other groups.

The study protocol asked for a fair amount of data from the participants. Their level of compliance with the protocol varied widely (see [Figure 7.2](#)).

7.2.1 Current Music and Communication Practices

I asked for a significant amount of information from participants about their existing music listening and communications practices prior to enrolling them in the study. The partici-

Table 7.1: Study 3: Participants’ First Languages

First Language	Frequency
English	17
English and a little bit of Hindi	1
English and Telugu	1
Turkish	1
Vietnamese	1

pants’ ages ranged from 12–67, with an average of 28.6, and a median of 24. Most participants’ first languages included English (see Table 7.1). How long the recruited participants had previously been using the Spotify streaming service varied widely as well. The participants’ “Spotify ages” ranged from 0 years (brand new Spotify subscribers) to 9 years (people who have been using Spotify since it was released), with an average of 3 years. Participants reported utilizing myriad means for keeping in touch with their friends and/or family members (family) (see Figure 7.4) with varying frequencies (see Figure 7.5).

I hoped that participants’ experiences with CoListen might affect how frequently participants felt lonely. The participants I recruited did report feeling lonely. Approximately half of my participants reported feeling lonely at least “once a week” (see Figure 7.6). Eleven of my participants reported listening to music “most of the day on most days”, fourteen reported listening “some of the day on most days”, the remainder listened a bit less (see Figure 7.7).

7.2.1.1 Music Listening Privacy

In order to understand more about how participants may use CoListen, I asked participants “Are there ever times when you would not want people to know what music you are listening to?” out of the 32 who responded to this question, they were nearly evenly split Figure 7.8. For those who selected “Yes,” I asked them to elaborate on what those circumstances might be. Some were worried that their contacts would misconstrue a relationship between the mood or lyrics of the songs they were listening to with their current state/mood: “...like either if the music has some problematic elements in it, like it could be heard as misogynistic or something, or if it’s like really angry or depressed, and I don’t want people to think that I’m angry or depressed just because I’m listening to that music” (P16). Others shared that they would not want their contacts to know that they were listening to a song on repeat either simply because they like it (P36), because they’re learning to sing it (P22), or because it is a good song to workout to (P40). One participant (P9) reported having a general preference for preserving their privacy: “Just generally I don’t want people to know my life. I don’t use the Spotify feature that shares my playlists with my friend list.” One participant who has a large Spotify following (P13) explained that they use Spotify’s private listening sessions feature for “...auditioning music that I don’t know the quality of.” The other reasons

Table 7.2: Participants' time in the app.

Participant	Group	In-App	Overlap	Colistening
05	01	5:21:17	5:01:21	4:20:19
06	01	0:15:20	0:04:08	0:02:02
07	01	4:13:22	3:24:57	2:49:15
08	01	4:41:57	4:11:56	3:09:44
09	02	6:12:57	0:56:32	0:47:13
10	02	3:47:49	2:25:03	2:06:30
11	02	0:35:40	0:26:33	0:17:36
12	02	3:07:52	1:57:28	1:33:30
13	03	3:58:36	3:16:49	2:56:30
21	03	3:15:29	2:15:55	1:55:53
22	03	5:46:57	3:31:22	3:48:19
14	05	2:08:13	0:36:39	0:49:29
15	05	17:49:28	10:57:49	8:26:57
16	05	6:01:27	2:05:34	1:54:08
17	05	9:54:40	8:30:07	6:43:31
37	05	0:11:56	0:00:00	0:00:00
19	07	0:04:17	0:00:00	0:00:00
23	07	0:02:54	0:00:00	0:00:00
32	08	2:21:03	0:54:10	0:48:05
33	08	7:21:10	0:24:16	0:24:11
34	08	0:33:34	0:29:54	0:28:47

reported were that the participants thought that some of their guilty pleasure songs would be embarrassing, that they would not want it to be visible when they were listening to “romantic music,” or that they listened to extremely niche music that they simply think others would not enjoy.

7.2.2 System Logs

The CoListen app sent client-side events to be logged to our server in addition to the server logging its own events. In all, the participants logged a total of 3 days, 15:45:58 in the CoListen app, with a total overlap time (with other participants in their own group) of 2 days, 3:30:33, and a total co-listening time of 1 day, 19:16:42 (see [Table 7.2](#), [Figure 7.9](#), [Figure 7.10](#), [Figure 7.11](#), [Figure 7.12](#)).

Table 7.3: Study 3: How was the co-listening experience today?

Code	Frequency	Example Responses
Positive	32	“It was awesome. Getting the notification that one of my friends is listening with me was exciting and cool to think that we were both listening to the same songs. ” “Good but slightly glitchy” “It was great! I haven’t ever used an app where I can listen to what others are listening to with them in real-time, so this new experience was quite thrilling. ”
Neutral	19	“It was a little glitchy. Had to restart the app twice because of freezing/crashing.” “Fine”
Negative	4	“Frustrating. App kept freezing, and not working, requiring multiple restarts and logins.” “Difficult, the songs would not sync up and people were listening to different songs at the same time”
Buggy	16	“Frustrating. App kept freezing, and not working, requiring multiple restarts and logins.” “Good but slightly glitchy” “It was a little glitchy. Had to restart the app twice because of freezing/crashing. ”

7.2.3 Daily Diaries

In total, nineteen participants (from the twenty-one that completed the enrollment process and were eligible to begin the study) completed at least one daily diary. Participants completed a total of 169 daily diary responses. Participants indicated in response to diary prompts that they co-listened on a total of 73 days. In 14 of those diaries, from among 9 participants, the participant responded affirmatively to “Did you use CoListen with anyone today?” but our system logs seem to contradict their self report. In 2 diaries, participants reported not co-listening on days when our system logs show they did co-listen. Of all participants’ diary responses, eighteen participants reported on a total of 96 entries that they did not “...use CoListen with anyone today” (see [Figure 7.13](#)). If a participant responded negatively to “Did you use CoListen with anyone today?” they were offered no further prompts after “Why not?”.

The next question for those participants who responded affirmatively asked participants to reflect: “How was the experience?”. Of the seventy-three participant diaries that indicated they did use CoListen with a friend and subsequently shared how the experience was, many participants shared an experience that I coded as positive (see [Figure 7.14](#), *nota bene*, take special notice (n.b.) the incidents where bugs were reported were additionally coded as either

negative, neutral, or positive (see [Table 7.3](#)).

“I believe, so far, throughout the duration of this study I have used Colisten only once, maybe twice. Colisten as a concept is wonderful. I think it’s a great idea to be able to share music in real time with your friends. The limitations of the study such as app build, inability to directly integrate with the Spotify app, and having to coordinate with your friends when to get on the app decreases both the desire to use it and the self-efficacy to use it properly. However I will say that the process we all went through to install the app, learn how to use it, and the few times we did listen to music together did enhance our overall experience of friendship. I’m sure in the concluding questionnaire there will be more opportunities to discuss this further. I appreciate your time and willingness to let us participate in this study.” — P11

Overall, many participants had positive experiences and shared their enthusiasm for the prototype through their daily diaries and/or [CoListen Experience Post-Trial Questionnaire](#). However there were also many negative experiences due to bugs in the app, or in some cases the challenging enrollment process.

Participants reported using CoListen in several different places. By far the majority of diary responses (48) reported using CoListen at home (see [Figure 7.15](#)). Work was the second most-reported location with ten daily diary responses. While some participants were doing “nothing” else when using CoListen, usually they were also doing something else (see [Figure 7.16](#)).

Participants who co-listened with their [family](#) reported that they felt closer to/more connected with them (see [Figure 7.17](#)). Valuing “no” as 0.0, “sort of” as 0.5, and “yes” as 1.0, I generated box plots to illustrate the effect at the participant level (see [Figure 7.18](#)).

I also asked participants, “Did colistening change how lonely you may have felt today? How?”. Overwhelmingly, participants answered that they experienced no change due to colistening. While in the definite minority of responses, some did respond affirmatively.

“Yes. I felt like there was a lot of bonding that happened over trying something new together for the first time. And there was immediate camaraderie from discussing and sharing new music.” (P11).

“Yes. My friend played our song, which was sweet.” (P9)

7.2.4 Affective Benefits and Costs

Prior to the trial period, participants each completed two [ABCCTs](#). First all participants completed one for [Short Message Service](#) — the technical name for “text messaging” via

Table 7.4: Study 3: Participants' Activities Co-Occurring with CoListen Use

Category	Code	Example
hanging out	hanging out	"Hanging out with the family"
working	email	"Doing work, answering emails, on social media"
	homework	"Doing homework"
	studying	"Studying"
	working	"Doing work, answering emails, on social media"
	writing	"Writing a paper"
getting ready	getting ready	"getting ready this morning "
nothing	nothing	"Nothing"
phone use	playing game on phone	"Eating and playing a game on my phone"
	phone use	"Texting and doing stuff on my phone."
	browsing	"Browsing news stories online. "
	social media	"Doing work, answering emails, on social media"
	texting	"Texting and doing stuff on my phone."
	playlist	"Trying to figure out how to create a new playlist for myself"
eating	eating	"Eating and playing a game on my phone"
chores	cooking	"Cooking"
	cleaning	"I was cleaning my room."
	walking dog	"I was walking my dog at first and then later not really doing anything else"
exercising	exercising	"Exercising and texting"
	running	"Running."
	walking	"Walking "
driving	driving	"Driving home from an appointment."

Table 7.5: Study 3: Single-Respondent **ABCCTs**. Scales 1–4 are benefits (Emotional Expressiveness, Engagement & Play, Presence-in-Absence, and Social Support), and scales 5–7 are costs (Feeling Obligated, Unmet Expectations, Threat to Privacy) [118]. The values are from a 5-point Likert-type frequency scale with 5 being most frequent.

ICT	1	2	3	4	5	6	7
Facebook	4.0	4.0	3.0	3.6	1.0	1.25	2.0
Google Hangouts	3.67	4.0	3.67	3.0	2.75	2.5	1.75
Skype	4.0	3.67	4.0	3.8	2.0	2.5	1.25
WhatsApp	3.67	4.0	2.67	4.0	2.75	2.25	2.25

mobile telephone —) (SMS), and then they each completed one for another **Information and Communications Technology (ICT)**. The “other” **ABCCT** they completed asked them to choose the **ICT** they used most frequently (other than SMS) and complete the instrument for this. As you will see below, participants selected myriad **ICTs** for this.

On average, participants did not seem to consider **ICTs** to have significant affective benefits (see Figure 7.19 and Figure 7.20). For CoListen the **ABCCT** indicate that participants found the “Engagement & Play” scale of the affective benefits dimension to be the most beneficial relatively, followed by “Presence-in-Absence” (see Figure 7.19a). The **ABCCT** indicate that participants see CoListen as entailing affective costs least frequently in comparison to all other **ICTs**.

While it is not clear that participants conceive of CoListen as an **ICT**, it is interesting that even after approximately two weeks of use of the early prototype, they still do not attribute to CoListen significant affective costs.

7.2.5 CoListen Experience Post-Trial Questionnaire

Thirteen participants completed the questionnaire. I asked the participants how frequently they used CoListen as their music listening application during the duration of the trial period. Most participants used other means more often than CoListen (see Figure 7.21). The other ways participants listened to music varied widely. Because my recruitment fliers featured Spotify prominently, it is perhaps not surprising that Spotify was the primary way that participants listened to their music even during the study. The selection criteria for this study required participants to have regular access to an **iOS** device, so it is again expected that Apple Music or iTunes were popular alternative means of music-listening among my study participants. Based on the trend of YouTube’s popularity I found in similar populations in my earlier work (Table 5.1, [108]), it was also a predictable means represented in this data set. Other means such as “vinyl,” Pandora, and radio (especially in the car) were also reported, though less frequently.

7.2.5.1 Co-listening Experience

The CoListen prototype was evolving even during the study (as I responded to participants' reports of bugs or other difficulties). As this was the first broad deployment (outside of lab and **family** dog-feeding), there were a significant number of bugs. Participants who started on different days had different first experiences with CoListen.

I asked participants, "How did it make you feel to co-listen with your friends?". Participants reported a range of feelings from not feeling anything, to feeling entertaining, and even to feeling like a party (see **Table 7.6**).

Interestingly, in contrast to participants' daily diary responses nearly unanimously reflecting a lack of any effect colistening may have had on their loneliness, two participants indicated in this post-trial questionnaire that they thought co-listening did affect their loneliness.

"If I was working by myself it was nice to know other people were sharing something with me" —P6

"It made me feel less alone. Knowing someone was 'subscribed' to my music and listening to whatever song I was at the same time made me feel like I was with that person, or at least interacting with them." —P33

7.2.5.2 Music Listening Behaviors

In implementing **CoListen v1.0**, I had to make tradeoffs. Rather than spend time re-implementing all of Spotify's (and all other streaming music players') features, I had to select a subset that would make it possible to use CoListen at length, but not such a large set that I would require a full team of developers to finish the prototype. For **CoListen v1.0**, I decided to only support playback of CoListen users' existing Spotify playlists (that is, there is no interface in CoListen for creating or modifying playlists, the user would need to open Spotify to manipulate their library, and then refresh their library in CoListen). In the post-trial questionnaire, I asked participants (who would have just worked to use CoListen as their primary music player for two weeks) about their usual music listening behavior, *"Please describe how you typically listen to music (e.g. 'I set it and forget it. I put something on (e.g. 'station', playlist, artist, album) and then just more or less let it play.', 'I search for something I'd like to listen to, and maybe continue listening through a few related tracks, but soon perform the next search, relying more on my search activity than whole albums/artists or my own/others' playlists.')*".

For some participants the limited functionality of CoListen matched closely to their usual music-listening practices: "I usually use playlists, or if I do shuffle, I skip anything that doesn't appeal to me at that moment, till I find a song that does." (P22), "I just pull up a

Table 7.6: Study 3: “How did it make you feel to co-listen with your friends?”

Participant feeling co-listening

5	“It was a good time. Like a little discrete jam session.”
6	“It was pretty fun.”
7	“good! like a party”
8	“It was particularly engaging when multiple people co-listened together (3+) – the connectivity aspect was best for me on those days”
9	“I didn’t feel any particular way listening with others.”
10	“It was fairly entertaining I suppose, I would sometimes try to pick a particular song depending on who was listening as a joke”
13	“I liked co-listening but generally didn’t have time to do it other than when at home together anyway.”
21	“It felt nice that I could listen to the same song with my family.”
22	“We were usually together, so normal.”
16	“I mean, I was mostly excited to show them the songs I chose in my playlist. I did realize only after ui had listened to the playlist a bit that even a cover of Gin and Juice is not a super family-friendly song.”
32	“It was nice, especially because I wasn’t the only one listening to songs then.”
33	“It made me feel more connected to them! And not as lonely.”

playlist and then listen to that because I generally enjoy the songs that I’ve put in there.” (P32), “I go to a playlist that I want to listen to and usually shuffle it. If I don’t shuffle it, I will start with the song of my choice and then go scroll through and keep choosing songs of my choice” (P33).

For other participants the limitations of CoListen were a moderate inconvenience: “Create playlists and search for things to add to it.” (P13), “Generally, I choose an album or Spotify playlist, and listen to it while I’m working.” (P16). Still other participants found the existing-playlists-only functionality of CoListen to be a deal-breaker with respect to relying on CoListen as their primary music player: “I put all my music on shuffle or listen to one of my own playlists.” (P6), “I usually pick a station or artist and let it play and skip songs I don’t like” (P7).

7.2.5.3 CoListen Performance

The CoListen app is an early research prototype. While participants were able to log quite a few hours in CoListen (see [Table 7.2](#)), all participants experienced buggy behavior with varying regularity. Some participants (especially group 5 and group 3) reported frequent disruptions, e.g. “It worked well about half of the time” (P22). Other participants reported

occasional bugs that they felt able to recover from easily, “good! a few bumps here and there but usually closing and reopening the app helped” (P7).

The questionnaire asked further whether participants liked CoListen. Only two of the thirteen respondents gave an unqualified affirmative, “I liked it personally. It’s a lot of fun listening to a song with a friend at the same time, because we can always talk about certain songs and be able to bond.” (P32), “I did like it!! Before using it I had anticipated that I would feel different, more ‘connected’ to somebody if we were both listening together. When I actually used it this came true and was a feeling that was really neat.” (P33), “I do like Colisten, especially conceptually. I feel it would be best implemented as an integration or tab on the Spotify app, that would allow you to see what your friends are listening to (like currently on Spotify desktop) and drop in on their listening if you desired.” (P10).

Most others responded affirmatively, but with varying degrees of qualification, “Yes, I would say I enjoyed it.”(P21), “Yeah it was pretty cool!”(P6), “yeah I thought it was a fun way to engage with my friends through music” (P7), and “I like the idea of colisten, but I can only see it being used in certain scenarios.” (P5). Only one person responded wholly negatively, “Not really.” (P24).

Participants shared bugs they encountered and ideas they had about future directions for CoListen in the daily diaries, and in three of the questionnaire questions (“How did it go? Did CoListen work well?”, “Did you like CoListen?”, and “What improvements or changes would you like to see in future versions of CoListen?”). The bugs participants encountered can be categorized as follows:

1. delay between co-listeners
2. losing synchronization with co-listeners
3. dropping co-listeners
4. change who is controlling the music
5. “connectivity issues”
6. app appears unresponsive
7. inability to sign in
8. on some (smaller) devices, a co-listener’s picture may cover some of the metadata of the currently playing track

Through those same means participants also requested functionality (essentially to completely re-implement Spotify’s feature set, but with co-listening):

1. ordering tracks in playlists

2. filtering tracks in playlists
3. list more metadata in playlist track listing
4. browse albums
5. play albums
6. access Spotify generated playlists
7. search for tracks
8. creating/editing playlists
9. manage the queue
10. support podcasts as well
11. show what friend is listening to
12. “listen to more than just playlists” (one participant mentioned “Your Library”)
13. mode in which CoListen would automatically connect me to my friend’s music if they’re playing
14. ability to send a notification to friend(s) to invite them to CoListen in the moment
15. notify when friends come online
16. message with others in the app

Participants were not always sure what to expect of CoListen (though in some cases it was actually more to do with Spotify). One participant explained that they knew they could create playlists to facilitate using CoListen’s limited functionality, “...but that took a bit and I was worried that by downloading [sic] particular things, I might influence the Spotify recommendation algorithm in ways I wasn’t sure I wanted.” (P16).

7.2.5.3.1 Connectivity Effects One particularly pernicious problem that faced participants was unstable internet connectivity. In streaming music, people may be accustomed to some requirement of connectivity, but (1) through buffering, even relatively length gaps in connectivity can be ignored, and (2) through pre-caching of music, a “streaming” music player can actually function satisfactorily without an internet connection.

However, a co-listening streaming music player (i.e. CoListen) is rather more dependent on a reliable internet connection. In theory, the app could also utilize pre-caching so as not to need to rely too-heavily on the connection for actually acquiring the user’s own music,

but to date *the only Application Programming Interface (API) for streaming music (i.e. the various platform-specific Spotify SDKs) does not support pre-caching*. Buffering music presents an interesting case, especially for CoListen as a third-party using the Spotify **iOS SDK**. In fact, the **SDK** implements buffering, but because the Spotify code is closed source, CoListen can only interact with it through its public **API**. Because (1) the **SDK** maintains its own connection (see [Figure 6.2](#)) to the Spotify servers and manages the requests for content and (2) the **API** is unreliable in updating its client (my CoListen code) about various events, it is technically impossible for CoListen to maintain a perfect representation of the state of the Spotify-related data. Therefore, whenever the **SDK** fails to notify CoListen about state changes, they cannot be synchronized with co-listeners.

When the **SDK** fails to make or fails to receive a response to a network request, there is eventually evidence of this to the user (the playlist/track they requested is not played, or perhaps the music stops altogether). However when the CoListen app fails to communicate with the CoListen server, co-listeners' representation of the client's state cannot be synchronized (though admittedly the app could do better at representing the state of the connection or the fidelity of the synchronization in the user interface).

7.2.5.3.2 CoListen System Problems There were a few relatively major problems that occurred during some participants' trials that I had to repair during the study:

1. Notifications were not functioning correctly for a significant period of groups' trials.
2. A specific notification wasn't functioning properly
3. No one could sign in to the app for a short period.

There was a regression in the CoListen app and until May 9, 2018, the *key* notifications that would inform a CoListen user that they now have a listener or that they have just lost a listener were not functioning reliably. Only since June 1, 2018 would a CoListen user receive an audible notification when they "friend" to whom they were listening become unavailable. On May 22, 2018, for a few hours the virtual machine hosting the CoListen server application exhausted its available disk space, but it turns out that no participants were active during this time (see [Figure 7.1](#)).

7.2.6 Interviews

I conducted nine interviews with all those participants who responded to my scheduling attempts. In one of the nine interviews, all three participants (cohabiting family members) were present on the phone at once.

Among other questions I asked participants during the interviews, I also asked how they coordinated their co-listening. In all of the interviews they reported some level of coordination. Texting (SMS) was popular, with participants in five of the nine interviews reporting they used texting for coordination. In the case of two groups, they mostly used CoListen when they were in relatively close proximity. Group 1 comprised four graduate students who were either in the same lab group or physically proximate lab groups. Group 3 comprised three family members who lived in the same home. Participants from these two groups (1 and 3) reported just shouting to their CoListen “friends” to coordinate co-listening. One participant also reported having called their friend to coordinate co-listening.

7.2.6.1 Participant Recruitment and Incentives

During several participants’ interviews, I learned that the participant knew of or encountered others who they believed to be interested in CoListen. Perhaps I could benefit from incentivizing recruitment further in future studies (for this study the only incentive was being able to begin the CoListen trial once your group had sufficient enrollment).

7.3 Discussion

Participants found time for co-listening (see Figure 7.12). While the total amount of time in the app, overlapping with group mates, and actually co-listening varied (see Table 7.2), the participants logged a significant amount of time in the app (see System Logs). There does indeed seem to be room in their lives for co-listening (RQ1).

Participants liked CoListen. From their daily diary responses asking, “How was the experience” (see Figure 7.14), their CoListen Experience Post-Trial Questionnaire responses (see CoListen Performance), and their interviews, it is clear that synchronized, co-listening, with previously-known contacts (family) was enjoyable. In many cases, participants reported that co-listening with their family helped them feel more connected (see Figure 7.17 and Figure 7.18). From this study, I have promising data about the potential for co-listening with family to prove meaningful to participants, particularly in helping them feel together with their co-listeners (RQ3).

CoListen is designed in an attempt to support “mere togetherness” [110] through implementing a form of phatic communication that might facilitate people “sharing empty moments” [70]. The idea is that by minimizing the disruption to the individual through limited notifications and excluding support for features such as text chat or more egalitarian control over the shared music, CoListen supports the listener in balancing their local needs (whatever the person may be doing) and their need to feel together with a remote friend. Because CoListen is so committed to excluding distractions from the participants’ broader experience, it places friends in a rather unique relationship to the app. When a person selects a

playlist or track to listen to, they have immediate feedback as to their success in effecting a change in the state of the app, and to the interpretation of their input by the application: did the selected song or playlist start playing? However the novel interaction that CoListen attempts to support is remote, synchronized, co-listening. Because of the lack of features such as integrated chat, CoListen provides no reassurances that the initiation of co-listening has succeeded. Further, even if the initiation of co-listening succeeds, CoListen also lacks reassurances that the synchronous co-listening relationship is being maintained.

Participants in the study experienced varying levels of unexpected or even buggy behavior. Once they began to question the state of the app, they may also question the state of the synchronization with their friend. Intentionally, CoListen does not implement some features that users might otherwise use to diagnose the state of the system (e.g. text chat with friends and/or co-listeners) out of concern that doing so may compromise the design goal of limiting disruptions from the app. During the design of [this version of CoListen](#), I did not prioritize features that might help provide diagnostic information to the users. Further work is needed to see if features that provide such information can succeed in helping CoListen users trust that they are having the synchronized listening experience they expect, without impinging on their local needs. While I know that participants like co-listening, and that they found the experiences meaningful, I also have some data to help understand more about designing for co-listening (see [RQ3](#)).

7.3.1 Limitations

In designing CoListen, especially in designing its notifications, I paid special attention to precisely which events could trigger a “noisy” (user-detectable, potentially disruptive) notification. At the risk of collecting less data from the study, I chose to implement extremely limited (user-perceivable) notifications. Crucially, from the start of the study until May 9, 2018 (so after two groups were entirely finished, and after three others had begun) these carefully crafted notifications were not working reliably. In the [CoListen Experience Post-Trial Questionnaire](#), I asked participants whether they realized when they had friends listening with them. Of the thirteen who responded to the questionnaire, only one (P16, who completed the study prior to the aforementioned software fix) responded that they *did not* realize.

The study protocol emphasized having enough people in a group to begin the trial. It was difficult to coordinate the participants. Once all participants completed the enrollment steps, I would release the app to all members of their group. However this release event may have corresponded to no meaningful time in the participants’ schedules. At best it was relevant to the lagging group member who last completed their last enrollment requirement. So the group members could start using the app any day after this point. I attempted to only start prompting them for their daily diaries once all of their group members had at least launched the app. Tracking the group members’ progress in beginning the trial was a relatively manual

task, so it is possible that participants were not prompted to reflect on their experience with CoListen on the first day or two of use. Because some participants were lagging behind the others in terms of not only enrolling, but (possibly different members) in beginning to use the app, I would eventually become worried that certain group members may never join, and in an attempt to remain true to my protocol and not to oblige participants for daily responses any longer than agreed, I would start the daily diary prompts for those group members who had launched the app, even before all their group mates were using it. Ideally in future work, I would at the very least configure a tool to alert me (e.g. via SMS) when each of the (or even only after all) members of a group had begun using the app. In fact, it would even be possible to only alert me when too much time is passing between group members beginning to use the app, and have the system itself begin the prompts once it noticed all members had launched the app.

In addition to fixing some of the notifications on May 9th, 2018, it was also only on this date that I noticed “Naggi” — the service that would prompt participants after 48 hours of no activity in CoListen — had crashed, and restarted it.

This work was also limited by the recruitment processes. Manually processing participants, along with attempting to grant them all access to the application simultaneously, meant requiring the enthusiastic early adopters to wait for the lagging group tag-alongs. This could have tempered participation.

Additionally, while two weeks was sufficient to smooth over some of the ebbs and flows of our participants sometimes hectic schedules, perhaps a longer deployment would have been more informative.

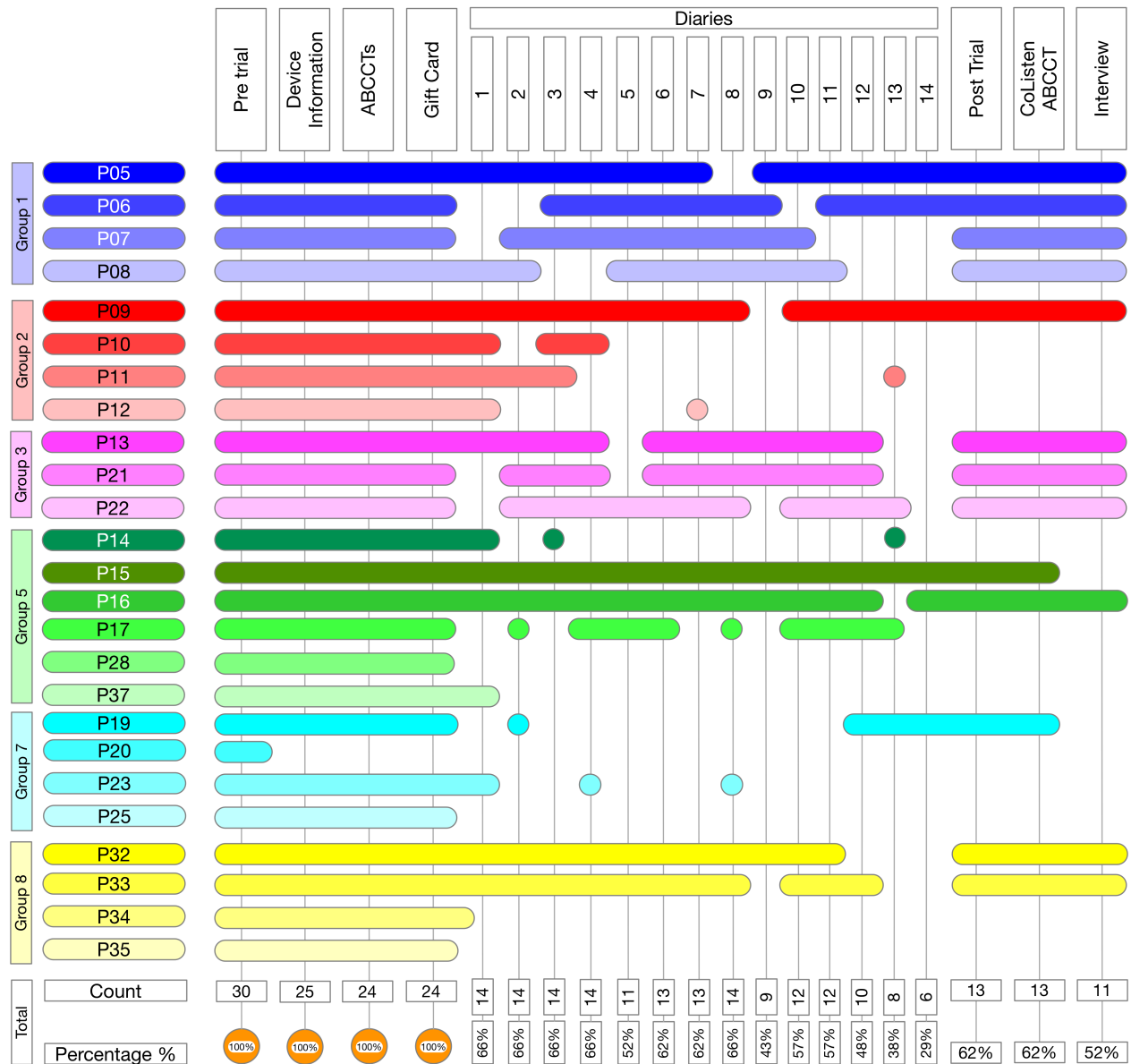


Figure 7.2: Data selected from participants during each phase of Study 3: CoListen in the Wild.

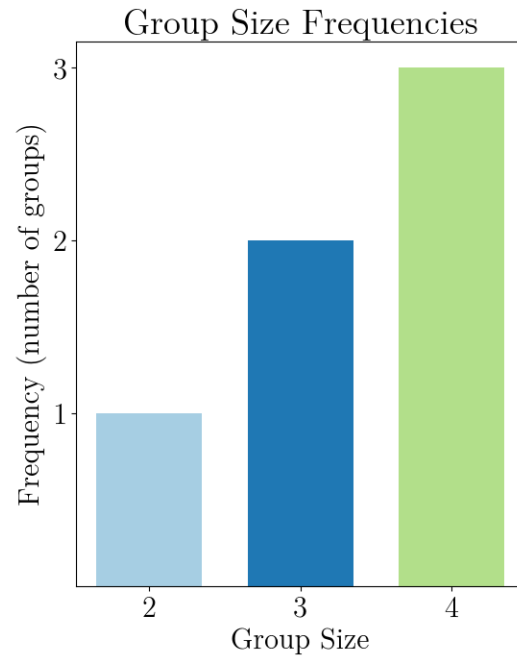


Figure 7.3: Study 3: Group Sizes

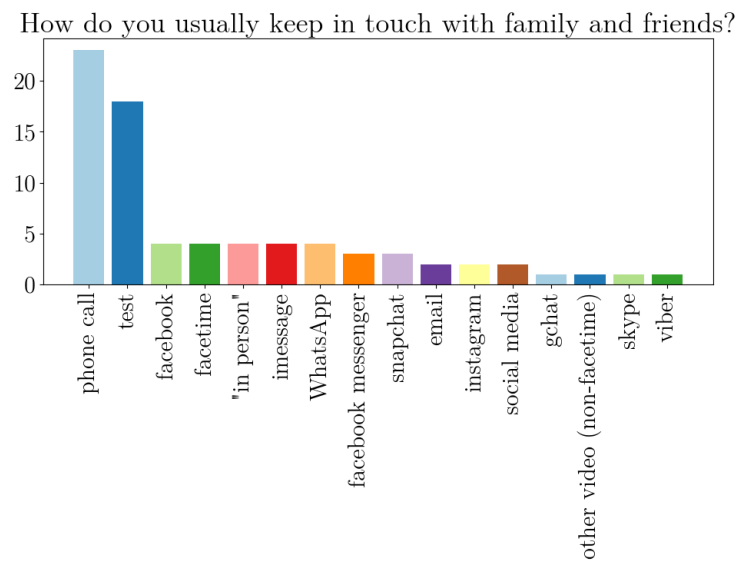


Figure 7.4: Study 3: Information and Communications Technologies (ICTs) Utilized to Keep In Touch (KIT) with Framily

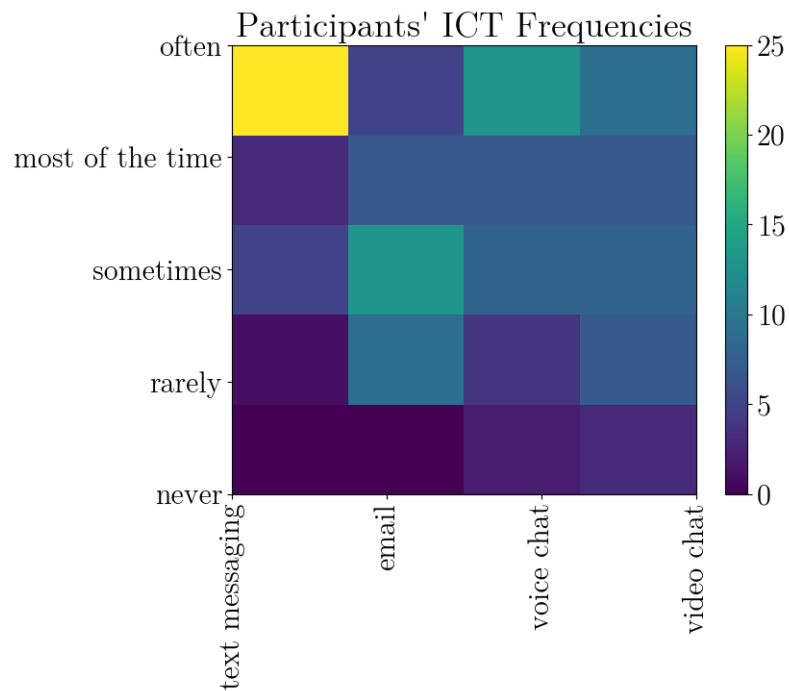


Figure 7.5: Study 3: ICTs Utilized to KIT with Framily

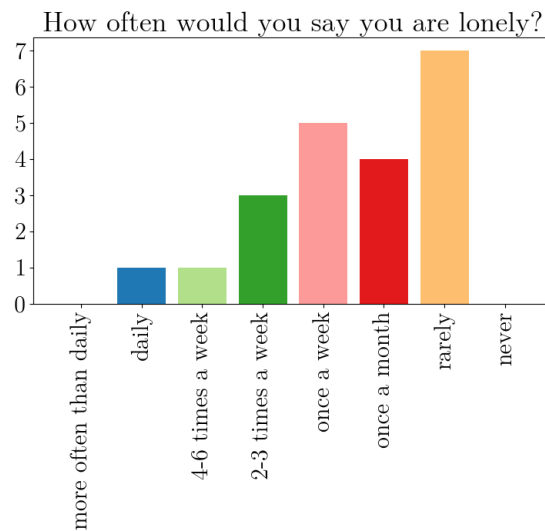


Figure 7.6: Participants' Loneliness Frequencies

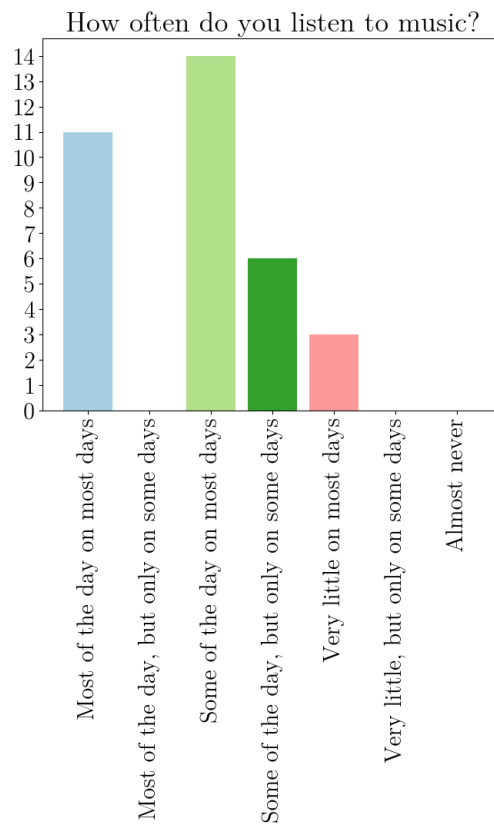


Figure 7.7: Participants' Music-Listening

Ever times for private listening?

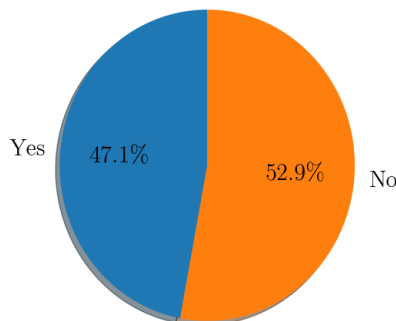


Figure 7.8: 18 of 34 participants responded that there are times when they would like to listen privately.

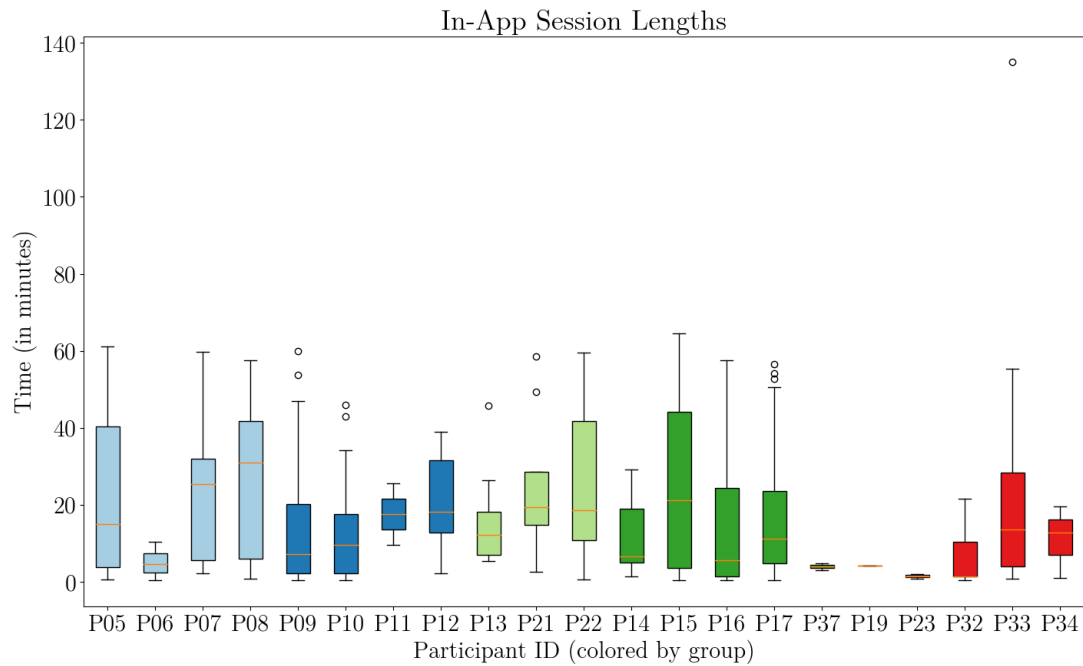


Figure 7.9: Participants' total time in CoListen

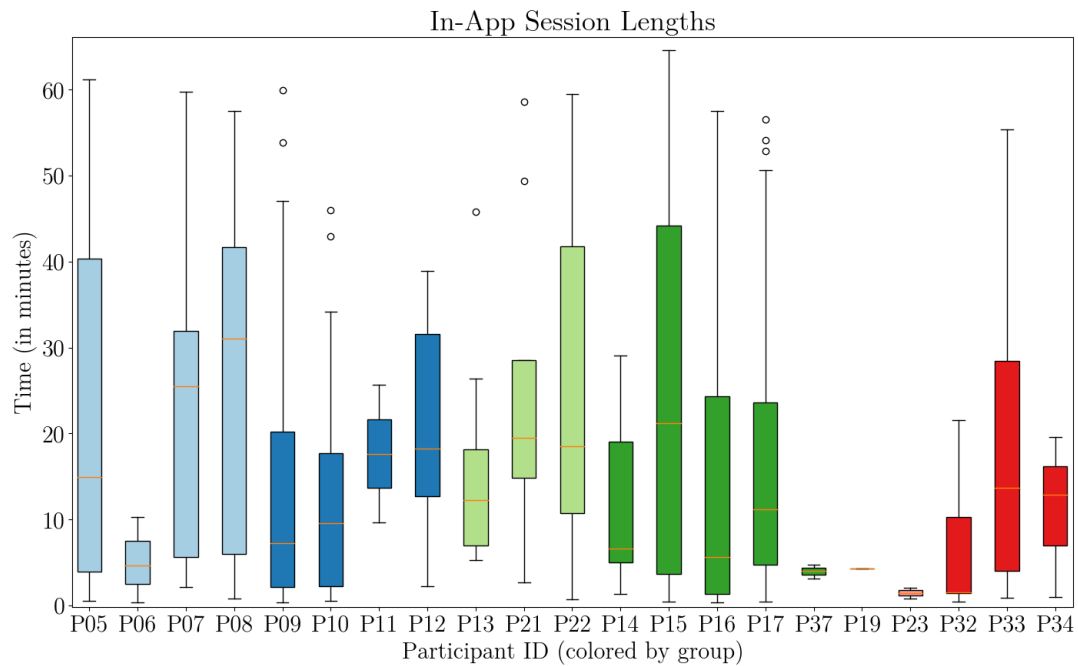


Figure 7.10: Participants' lengths of time in CoListen, missing 1 outlier

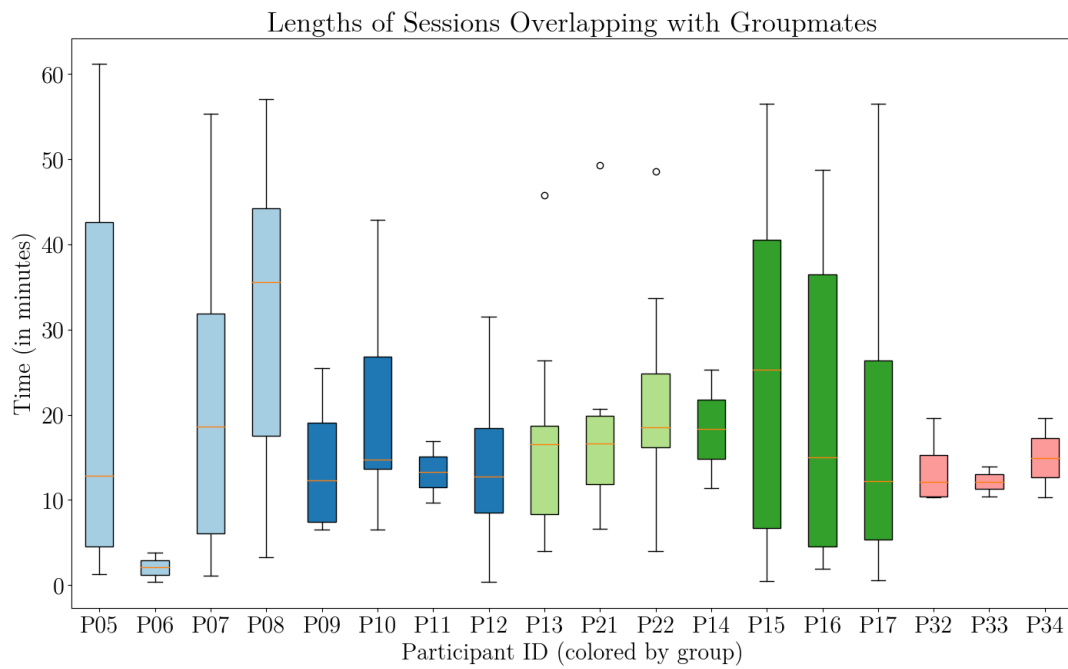


Figure 7.11: Lengths of time for which participants' CoListen use coincided with others in their group.

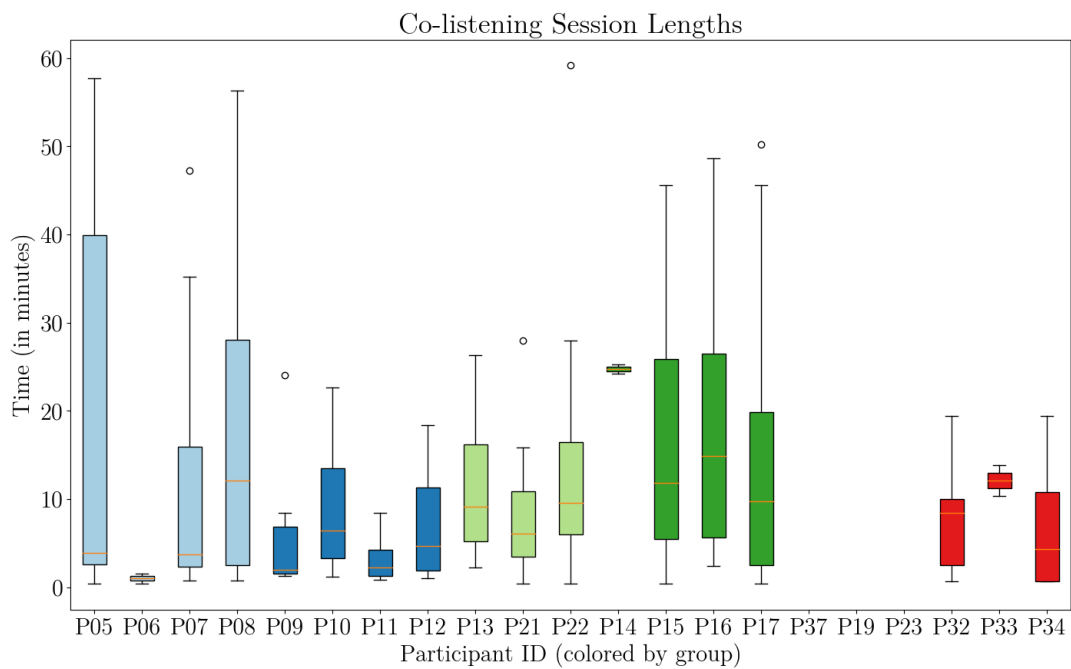


Figure 7.12: Participants' co-listening sessions

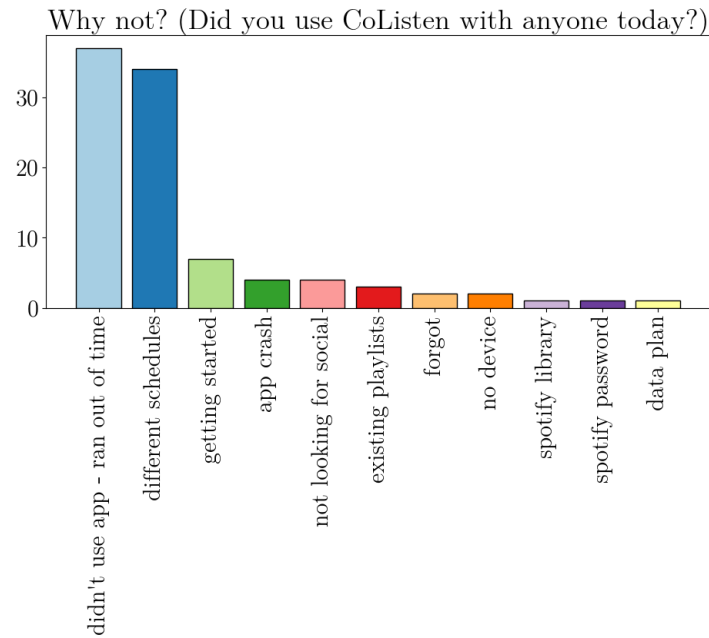


Figure 7.13: Coded responses for why a participant did not use CoListen with anyone today

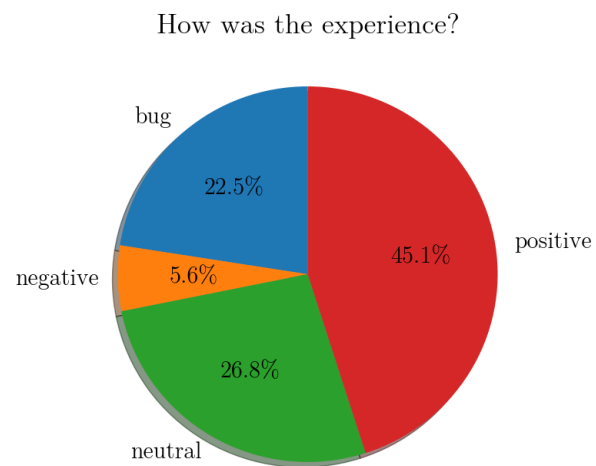


Figure 7.14: Coded responses for how the co-listening experience went today.

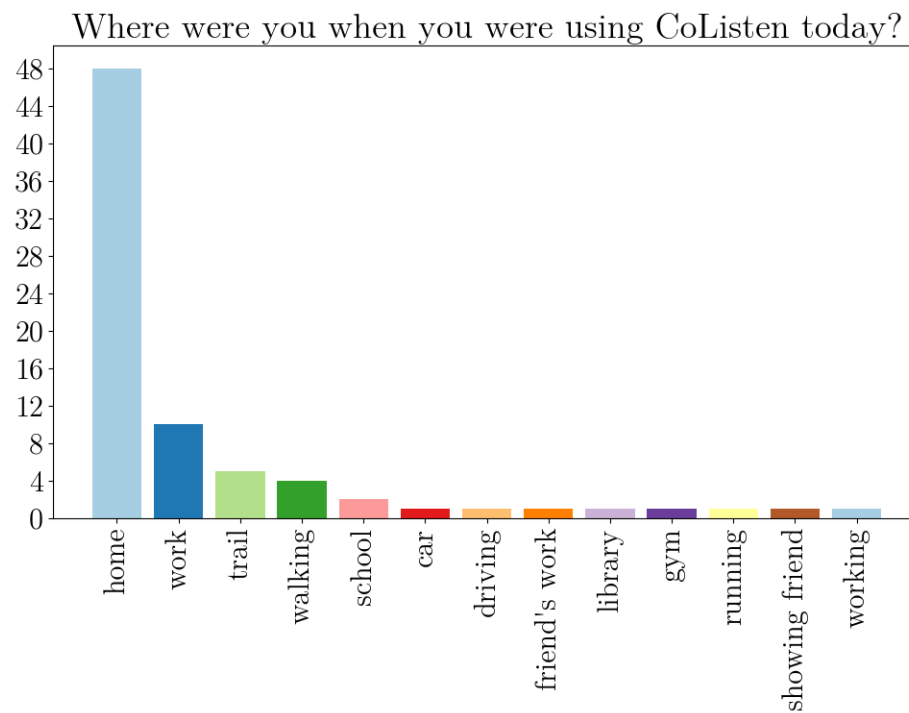


Figure 7.15: Coded Locations of CoListen Use.

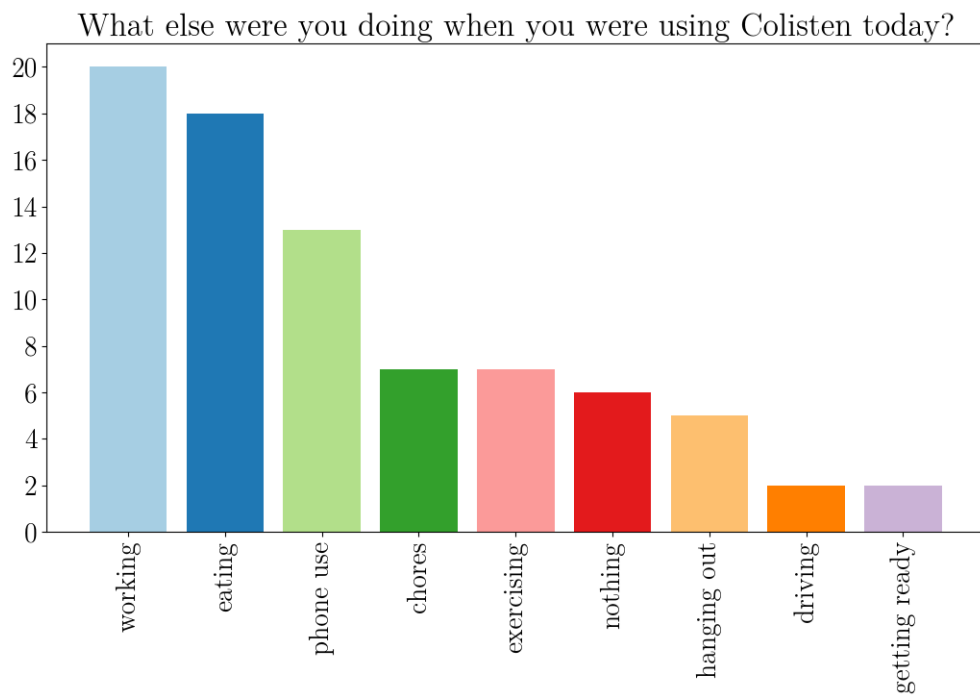


Figure 7.16: Coded Locations of CoListen Use.

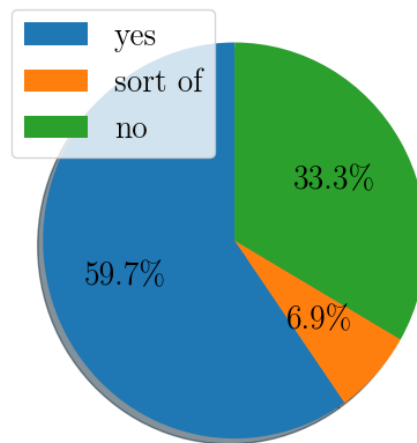


Figure 7.17: Closer for Co-Listening with 72 responses.

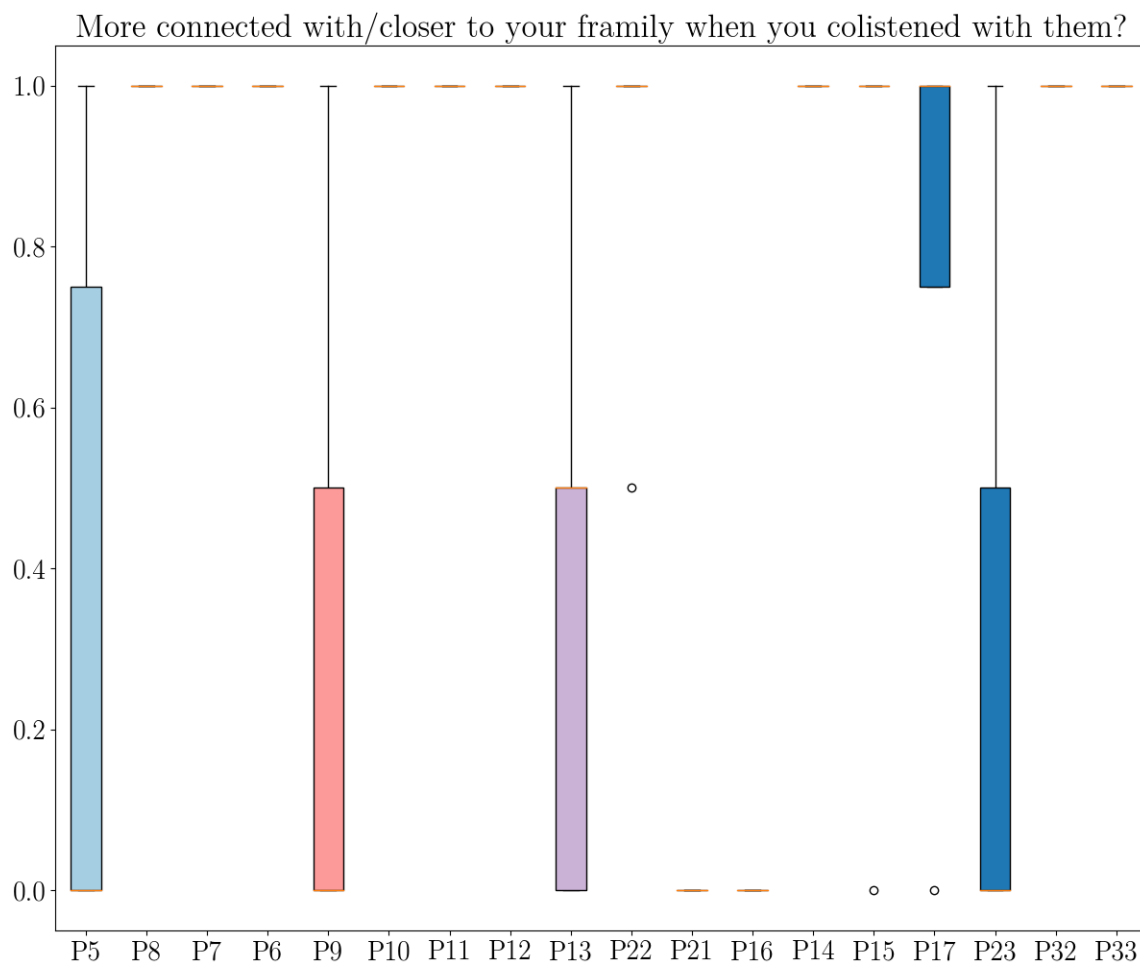


Figure 7.18: Closer for Co-Listening, by participant

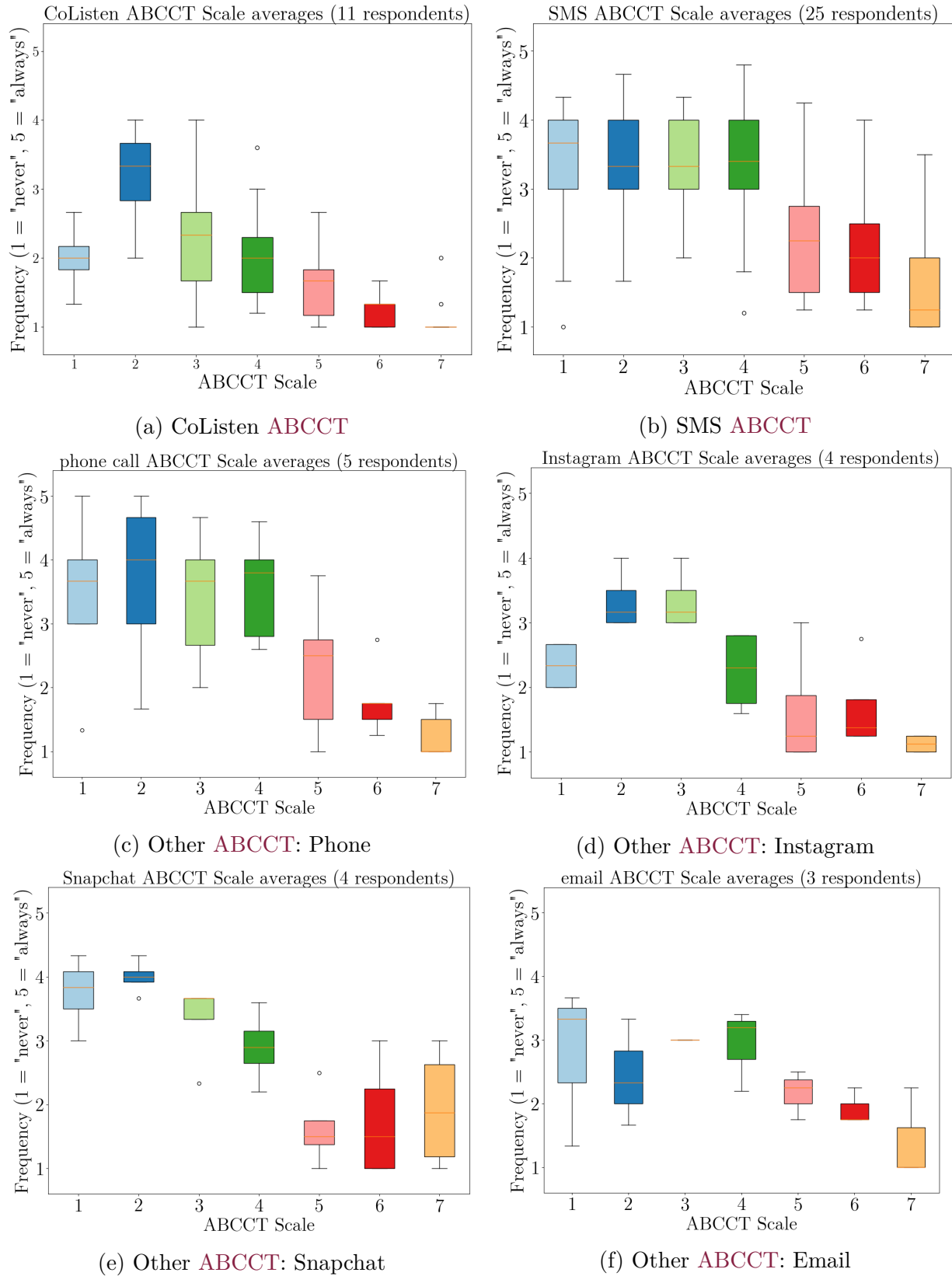


Figure 7.19: CoListen, SMS, and Most Frequent Other ABCCTs

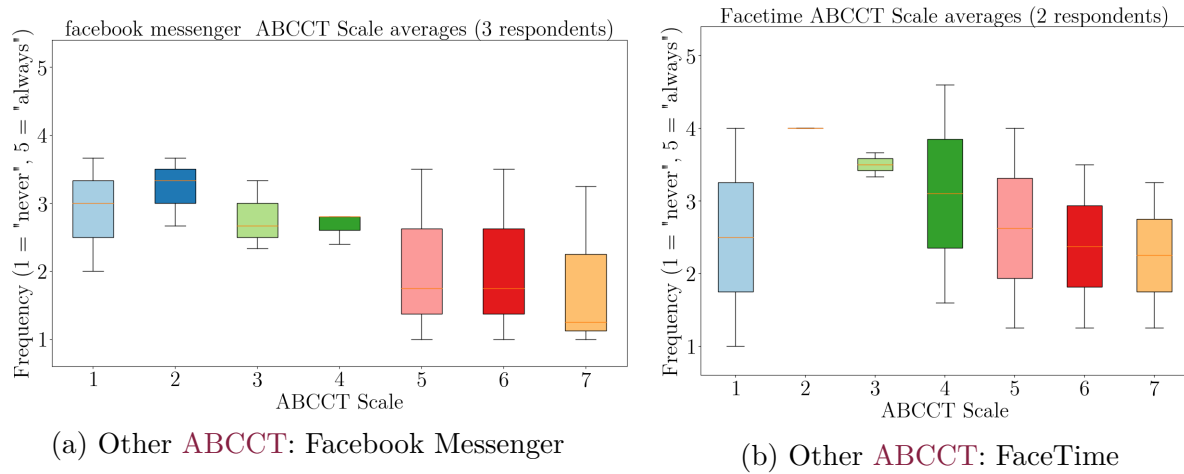


Figure 7.20: Other ABCCTs: Least Frequent

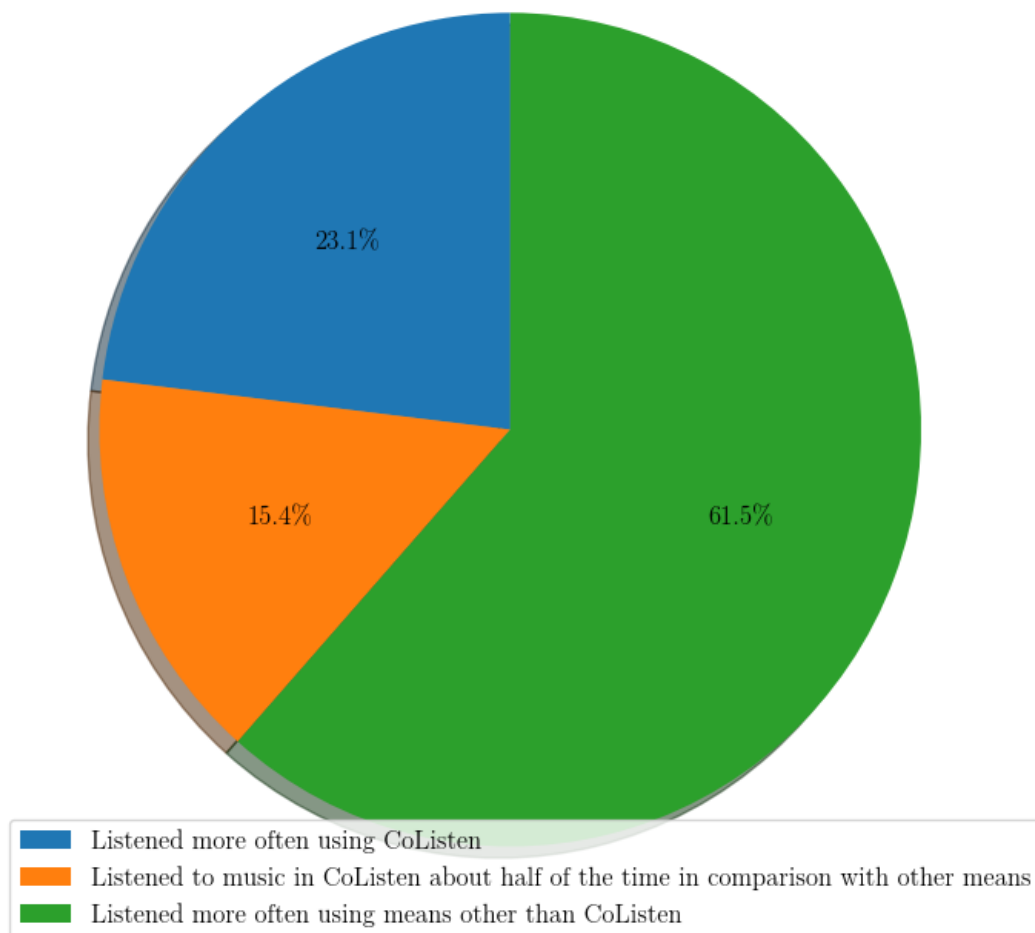


Figure 7.21: About how often did you choose to listen to music in CoListen compared to other options?

Chapter 8

Discussion

In this dissertation I have investigated *technological facilitation of feelings of togetherness with remote family in a way that balances people’s need for such connection with their immediate local needs*. The preceding sections have mostly chronologically detailed the progress of this work from **Study 1** and the **First CoListen Prototype**, to the in-the-wild deployment of **CoListen v1.0** in **Study 3**. In this chapter I will focus less on the particular studies and chronology, and instead on the research questions, outcomes, implications, and future directions. In the next section, I review the **research questions** and the findings relevant to them.

8.1 Design Space

My **first Research Question** was about whether there is space in people’s lives for co-listening. While it is not largely available to most people, synchronized co-listening is not so far from our current experience of (e.g.) **Information and Communications Technology (ICT)** use such as video-chats or phone calls. In **Study 1: The Diary Study**, I found that participants (1) listen to music, (2) use **Information and Communications Technologies (ICTs)** to keep in touch with friends, and (3) participate in **phatic communication**. Participants of the study used existing **ICTs** to transact their phatic communication, but at what cost[114]? Though they communicated with each other and listened to music frequently, participants rarely listened to music with their friends. Prior work in various ways to share music have explored other aspects of sharing, sharing in other contexts, for different reasons, or with different people. In **Study 1** I found evidence that there may be a design space for co-listening within existing interpersonal relationships in the context of people’s daily lives (**RQ1**). From **Study 2: CoListen in the Lab**, I learned that participants were interested in co-listening with each other, that they may be interested in support for more than dyadic co-listening, and that they had some concern about their personal image management with respect to their peers in co-listening (**RQ1** and **RQ2**). Further, through the participants trial of my prototype (see: **CoListen v0.1**), I learned that they would like the opportunity to use CoListen in their daily lives. In **Study 3: CoListen in the Wild** I saw that despite differing schedules and some problems with the app, people actually used **CoListen v1.0** to co-listen with their **friends and/or family members (family)**.

My **second Research Question** is about how people imagine the design space (between listening and communicating) for co-listening. The most significant contributions to my understanding of the design space came from **Study 2**, especially the **Design Charrette**. From my participants' designs, **a dimension of the design space** emerges as co-listening being somewhere between a primarily social experience with the addition of music listening, and primarily listening to music, with some sociality added. How co-listening should be initiated was also an interesting dimension from participants designs. Many participants designed the interaction, similar to a phone call, where a first participant would propose the session to the other (as in dialing their number on the phone), and then the recipient would accept or decline the session (pick up or ignore the phone call). However other participants imagined different interactions that spanned the whole gamut from "listener (just) listens" (as in CoListen) to "broadcaster (just) plays" (see: **subsection 5.5.2.1**). Issues related to **Access** featured prominently in **Study 2**, as participants were concerned about issues from their parents' policies for when they could use their devices, to the cost of purchasing music, and the bandwidth required to co-listen.

From the charrette and debriefing following the prototype trial, I learned that my participants were far less concerned about disruptions of their lives from smart phone notifications than I was. Even after seeing my implementation of co-listening in action (which severely limits notifications), and even with prompts about how frequently they may receive notifications once they had several CoListen friends, participants still thought they just would not receive all that many notifications (i.e. many were content with the confirmations required to initiate each co-listening session). On the one hand, this could have meant that participants simply could not imagine the burden without experiencing it, in which case I would learn more in **Study 3**. On the other hand, this may lead us to question how disruptive people find mobile notifications. Perhaps approximately ten years later, it would be difficult to replicate Turkle [114]'s findings now that our expectations, practices, and interfaces have evolved?

8.2 Experiencing Co-listening

Through the trial of **CoListen v0.1** in **Study 2** and an in-the-wild deployment (see: **Study 3**) of **CoListen v1.0**, I was able to learn about people's experience with background co-listening for togetherness (**RQ3**). In using the app with their friend in the lab, participants reported enjoying the app and wanting to use it longer term outside of the lab. They enjoyed the ability to switch quickly between listening to their own music, and co-listening with their friend. This ability to switch quickly was only possible because of the initiation interaction design. In CoListen (both the prototype and v1.0 deployed in the wild), once a friendship is confirmed, one can begin listening to their friend who is also currently using the app without any confirmation from that friend. In addition to the ability to switch quickly between listening to their own music vs. co-listening with their friend, participants also expressed interest in how quickly the listener's device reacted when the friend's (listenee's)

device changed the music (e.g. selected a new playlist or track, skipped forward or backward, or toggled play/pause).

In the first CoListen prototype, one could see that their friend is currently listening to music in CoListen, but they could not see whether that friend was listening alone. One participant pointed out that when they are co-listening with a friend in CoListen, they are at the mercy of their friends music selections. The participant imagined the case where they were co-listening with a friend (listenee), and then another friend — a romantic interest — came online. That romantic interest may choose to listen to the participant. If the participant's listenee friend currently or eventually selected a song that would be embarrassing for the participant in the context of their (different) relationship with their romantic interest, this could prove problematic. For the second prototype (see: [CoListen v1.0](#)), I added in the ability to see whether your friend was playing their own music or rather was currently listening with another, so a CoListen user's friends would know — at least when deciding to co-listen with their friend — whether that person was listening to a friend, or to their own music. While this would help mitigate the image management issue raised by the participant, it fails to communicate another potentially interesting piece of information in the context of togetherness with family. Depending on the relationship between CoListen friends, it may be important to know when one listens to another that their friend is already listening with one or more friends. Consider again the case of a participant who is CoListen friends with a romantic interest. If those two (or however many compose the relationship) are listening to music with only each other, it could be a rather different experience than listening with a whole host of others who are not in the relationship.

Co-listening with [family](#) was meaningful for my participants. Many felt more together with their co-listeners (see [Figure 7.17](#) and [Figure 7.18](#)).

Participants also reported other interesting responses to the co-listening experiences. Some participants reported feeling obliged to listen to music in CoListen (or at least leave the app running, with music playing) longer than they would have otherwise when they had a CoListen friend (or multiple) listening with them. Several participants reported being interested in selecting music that their listener would enjoy. While the goal of CoListen is not to oblige app users to use the app more, the feelings of obligation expressed by the participants are encouraging in that they suggest that the phatic communication goals of CoListen were successful, and that the participants were indeed finding meaning in the act of remote, synchronized co-listening.

8.2.1 Attention

CoListen was designed to be primarily in the background (like most music players). A huge motivator for this was a concern that technology is continuing down a path of increasing enticement and even addictiveness. With injuries from people distracted by their phones on the rise [\[75\]](#), it is clear that we have succeeded in designing these enticing and absorbing

interactions. What could motivate a driver controlling an automobile weighing thousands of pounds, at high speeds, to try to read a text message they have received?!

People want to build and maintain their relationships, and will prioritize this need for human connection over many others. Might there be some way that does not require the person's immediate attention, for them to feel connected with their **family**? Perhaps some background activity could support the phatic communication that composes so many of our text messages.

...just when I thought I was out, they pull me back in! —Michael [83]

Not only are the applications that we might use on our phones interesting in their own right, but many use features that allow them to interrupt the user. In 2013, Apple had already delivered 1.5 trillion push notifications (after only 3 years of existence) [103], to say nothing of text messages or emails. Notifications of new email, or even just noticing new email messages in our inboxes when opening email for another purpose often result in users “getting lost” in email [36]. The majority of applications that use some notification feature to notify the user of some information are also prompting the user to launch their app in order to respond to the notification. CoListen is designed so that when you learn that a friend is now listening with you, you have no action to take. Of course the listener, upon receiving the notification that their friend is now listening with them, can choose to foreground the CoListen application, but there are no new actions available. The listener can select music from their playlists or a friend they would like to listen to, same as before their friend began listening to them. The notification in CoListen is not to prompt user interaction with the application, but to effect a change in the user's awareness of their remote **family** member. CoListen moves automatically from the periphery of the user's attention while they are listening to their music, to the foreground of their attention to provide the awareness of their new co-listener, and back to the background again as they continue their out-of-CoListen activity, but with the knowledge that they are sharing the listening experience.

Because I found that people were often doing other things while using the app (see: **Figure 7.16**, the goal of designing CoListen to be primarily in the background seems to have been successful. However some participants reported a more foregrounded experience as well, especially when they decided to use CoListen while colocated.

It seems that the participants were almost always aware that they were co-listening (see: **Study 3: Daily Diary Analysis**), despite the app often being in the background. This encourages me to continue with my approach of having as little notification as possible, knowing that I do not need to trade off participants' awareness of co-listening.

8.2.2 Trust

CoListen is designed to support remote co-listening, but with no added communicative features. This requires a level of trust be placed in the system by the participants. When a CoListen user selects a friend with whom to listen and music starts playing, that participant will only have the experience of co-listening if they believe that their friend is currently listening to more-or-less the same moment of the same song (as CoListen promises).

In designing the CoListen prototypes, I prioritized the playlist listening functionality and ability to synchronize playback with friends over all other concerns. The result is that the implementation offers no redundancy for confirming CoListen users' understanding that they are or are not co-listening at a particular time, and with whom.

While it would have been possible to develop the app such that the participants would experience no inconsistencies in the interface during their trial, not surprisingly the participants did encounter bugs. One kind of bug was that even though a participant had selected to listen to a friend, and even though (presumably) that friend's music started playing at the correct moment, and even though the participant's interface was updated to the (less playback control functionality) "listener interface", sometimes the interface would not indicate with whom the participant was listening, or would cease to report this after some time. This would leave the participant to wonder whether their contact was still co-listening with them, but with no simple way to resolve the uncertainty.

The systems that support our lives — including experiences like colistening, but also including mundane interactions with educational, corporate, and governmental bureaucracies — are becoming more complex, inscrutable. This inscrutability (due partially to their complexity, but in many cases due also to laws that protect the governing algorithms or other implementation details as intellectual property, or otherwise in the name of system security) requires a level of trust from the constituents of the socio-technical systems comprising these technological systems and the people who must interact with/through them.

Consider Google's project: Duplex [42]. Aside from (important, but well-documented) concerns about whether the people with whom the Google Assistant will interact on behalf of its initiator know it is not human, consider also the trust that both the initiator and the target respondent must have for the interaction to be successful.

Like CoListen's intention to remain in the background, Duplex has been designed to be capable of receiving delegated tasks that it can accomplish with little to no further attention from the initiator. Having completed the background task, Duplex will notify the user that their task is complete. For simple tasks such as booking an appointment (as demonstrated in the announcement), the notification displaying the appointment information should be sufficient to make the user comfortable that the task was completed successfully. However for some tasks, a user may have to simply trust the assistant that it has completed the task satisfactorily.

For CoListen going forward, the notifications will continue to be minimized. However people’s experiences with streaming and other connection-sensitive apps have conditioned us to expect to encounter occasional bugs as well as connectivity interruptions. CoListen’s audio and visual interface will therefore support more sophisticated status reporting. This will facilitate people in understanding the state of their co-listening with their **family** at a glance. Additionally, through the in-the-wild deployment in **Study 3**, I learned of more ways that the connection can be severed, and I will update CoListen to notify listeners when the last-notified-state is changed with out their interaction.

8.3 The Design and Development of the CoListen System

CoListen started as a spin-off from a project I was working on with Siroberto Scerbo, Nathan Self, and Chris Frisina. As it became clear that even a proof-of-concept “plumbing” together existing technologies (Spotify’s streaming music, with coordination between users implemented via some existing transport, such as socket.io [23]) would be rather complex, I first worked to find some evidence of the design space for remote co-listening in **Study 1**.

Proceeding then, I originally planned to use various web technologies with a cross-platform toolkit in an effort to make CoListen an app that could be deployed across **iOS** and android devices with a single code base. Further, using this technology stack would have allowed me to write both the client app (for both mobile **Operating System (OS)**s) and the server application that would facilitate coordination of the clients, in Javascript. This would facilitate on-boarding of additional project members such as undergraduate developers.

Two things became clear fairly quickly in developing **CoListen v0.1: The First Prototype**:

1. Undergraduate students are not very well versed in web technologies including Javascript
2. The cross-platform toolkits and their affiliated communities were not sufficiently mature for even a research prototype.

In addition to learning that I needed to re-implement the app using better-documented and better-supported technologies, I learned of some participants’ concerns and suggested features from **Study 2: CoListen in the Lab**. Most participants did not share my concern with being interrupted. Participants liked the **Co-listening Initiation** method demonstrated in **CoListen Testing**. Several participants expressed concern about managing their image with respect to their friends who may co-listen with them. Participants also thought the app was rather wordy, and lacking graphics.

In developing **CoListen v1.0** I tried to help allay participants’ concerns about misrepresentation, and to implement some of their suggestions. I did not decide to increase the amount

of notifications participants would receive as proposed by many participants in [Study 2: CoListen in the Lab](#). Perhaps one of the most difficult parts of developing [CoListen v1.0](#) was coordinating “messages” between the clients and the server. In order to rouse CoListen from the background (where most music players, and other apps spend the majority of their time), so that it could receive and even respond to messages, it was necessary to use the Apple Push Notification Service. The development process itself of developing in the Apple ecosystem, especially when including [Apple Push Notification Service \(APNS\)](#) is challenging (see [Push Notifications](#)). However, I now needed to coordinate consecutive messages from one client intended for another, possibly responses from the destination client back to the originator, and messages through [APNS](#). Though it is rather opaque to the developer (me) the communication between CoListen (actually the Spotify [iOS Software Development Kit \(SDK\)](#) code it uses) and Spotify’s servers is also happening amidst all these other messages (see [Figure 6.2](#) and [Figure 6.1](#)). Sequencing these messages is a real challenge. Following the D.R.Y. (Don’t Repeat Yourself) Principle, CoListen v1.0 attempted to maintain as little state as possible in the client and server, and to mostly let the Spotify [iOS SDK](#) maintain the state it needed, only querying for information (or in some cases attempting to mirror hidden internal state [Figure 6.5](#)). Keeping data in precisely one place and always performing so-called C.R.U.D. (Create, Read, Update, Delete) actions on it in that one place tends to prevent some bugs in software. This design decision, to rely heavily on the Spotify worked well in testing, but in practice with more diverse scenarios of use, it proved fragile, and the Spotify [Application Programming Interface \(API\)](#) unreliable.

8.4 Limitations

In addition to the specific limitations reported for each study (see those sections in [chapter 3](#), [chapter 5](#), and [chapter 7](#)), the situation of the CoListen project as a self-funded (with thanks to Dr. Deborah Tatar, and other groups within Virginia Tech, see the Acknowledgements) academic endeavor, as opposed to a for-profit venture may limit the applicability of some of the findings. The interaction design choices in CoListen that work to minimize the amount of the listener’s attention required by the app are possible because we can afford to design against the status quo [\[106\]](#) and are not selling the participants’ attention to advertisers.

One motivator for this work is the idea that if people feel more connected with those they care about through interactions such as co-listening, they may feel less compelled to attend as immediately to interruptions from the myriad software they use that give people even beyond their prioritized [family](#) access to them. We did not measure people’s need to attend immediately to these other interruptions in this work.

8.4.1 Access

The prerequisites to participate in co-listening as I have implemented it are rather extensive. Until I can develop CoListen for android devices, a participant would have to have an iOS devices (several hundred US dollars). Additionally, participants would need regular access to a high-bandwidth internet connection. Further, CoListen requires users have a Spotify Premium account (10 USD per month). While cultures and living situations all around the world may permit co-listening as a means of bringing family and friends together, even in the communities I am studying the people who meet these eligibility criteria must be rather affluent.

8.5 Future Work

Future work should include a truly public deployment in (e.g.) the iOS App Store and the Google Play Store (the latter entails a new implementation on the android platform, and both require agreements with Spotify, Inc). A longer deployment that more explicitly permits, or even incentives “snowball recruiting” (that the existing participants can invite their friends to join them later in the study), would allow for participants to have larger “friend” lists, and therefore their opportunities to encounter others in CoListen would be increased.

Participants of [Study 3](#) also reported being inhibited by the lack of features in CoListen, and so CoListen v2.0 will support at the very least the ability to listen to other elements of a Spotify user’s library than just their playlists, and preferably also search and playlist creation/editing.

As the participants’ networks within CoListen would potentially grow slowly, some participants’ feature requests to be able to notify another that they would like to co-listen is probably a good one. The next questions in adding such a feature are whether, how, and when to limit or phase out that capability.

It would be interesting in the future to attempt to measure participants’ average time to attend to notifications from their [family](#) through self-report or from access to the metadata of messaging applications that participants use most frequently.

[CoListen v1](#) reports in the friends list when a friend is listening to their own music vs. when they are listening to a friend (and therefore not directly selecting the music they are currently hearing themselves). Perhaps a future version should also indicate to people when they are in a one-on-one co-listening session vs. when either has other listeners. The meaning of co-listening with one other person may be different to those involved than merely being faces in a crowd of listeners.

8.5.1 Other Situations

The situations studied here (**middle schoolers** and **students in higher education**) were useful as first populations because they are representative of larger groups across the United States. Many other situations might also benefit from enabling media co-consumption in a way similar to CoListen. Some have already been the focus of related work and all are part of the picture of who might partake in the future.

8.5.1.1 Romantic Relationships

Remote relationships are notoriously difficult to maintain at a distance. “Intimate human relationships clearly require more [than current communications technologies afford]” [70]. Sharing in the relatively mundane details of daily life, just being there, helps couples feel connected. Perhaps by being able to co-consume media (in the first case, to co-listen to their music), couples might feel more connected. While I expect the effect would be more noticeable with remote romantic partners, I would also expect cohabiting romantic partners to experience feelings of togetherness when colistening while colocated or apart.

8.5.1.2 Working Adults

Working adults spend a majority of their waking time at their place of employment, and in most cases apart from their friends and family. As adults migrate for employment opportunity, and advance through life’s changes such as increased responsibilities at work or at home, they may find themselves with less time to devote to socializing with friends or extended family members. Many utilize **ICTs** to keep in touch and to coordinate with their friends and family.

8.5.1.3 Immigrants

People emigrate for countless reasons, but today people seeking refuge from violent conflicts and from economic hardship in their countries of origin is a topic of international attention. When people emigrate, they leave their whole lives and much of their existing social network behind. While they seek to build relationships in their new home, their friends and family back “home” can provide invaluable emotional support [86, 117].

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Appendices

Appendix A

Study 1: The Diary Study

A.1 Study 1 IRB Approval



Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-3732 Fax 540/231-0959
email irb@vt.edu
website <http://www.irb.vt.edu>

MEMORANDUM

DATE: May 1, 2018
TO: Deborah Gail Tatar, Michael Clark Stewart
FROM: Virginia Tech Institutional Review Board (FWA00000572, expires January 29, 2021)
PROTOCOL TITLE: Colisten Diary Study
IRB NUMBER: 15-347

Effective April 20, 2018, the Virginia Tech Institution Review Board (IRB) approved the Continuing Review request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As: **Expedited, under 45 CFR 46.110 category(ies) 7**
Protocol Approval Date: **May 7, 2018**
Protocol Expiration Date: **May 6, 2019**
Continuing Review Due Date*: **April 22, 2019**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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IRB SPECIAL INSTRUCTIONS:

****At your earliest convenience, please submit an amendment to update personnel. At least one of the students is listed as inactive in the VT system.****

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

A.2 Recruitment

I distributed the following flier to recruit participants to my diary study (Study 1).

The Third Lab at Virginia Tech is interested in understanding 9-15 year-olds, their friendships, communities, and whether and how they listen to music. We are conducting a research study, and may publish the results.

We will ask participating 9-15 year-olds to complete a short (5-10 minute) questionnaire each day for 14 days.



Please email Michael Stewart at tgm@vt.edu to express interest, get more information or enroll your child in our 14-day study. Participants will be compensated. Your child's participation is voluntary and confidential.



A.2.1 Recruitment Questionnaire

In order to consider a participant for enrollment, their parent or guardian had to submit the following questionnaire (which included their consent).

Default Question Block

Colisten Diary Study

Investigators: Michael Stewart, Deborah Tatar, and other investigators approved by the Virginia Tech Institutional Review Board

Purpose of this Research/Project: We are studying how people aged 9-15 keep in touch with each other, and listen to music.

Procedures:

The time commitment from your child will be just a few minutes each day for 14 days. At any point you or your child can ask the researcher for a break, or if you or your child wish, we can terminate the session completely. The researcher will contact the

child via email or text (SMS) message once each day for each of the 14 days. This contact will be a request for your child to complete a brief questionnaire asking about their communication with friends that day, and asking about their music listening for that day.

Risks:

The risk is minimal. The only risk is that the participant does not enjoy the study. The participant may terminate their involvement in the study at any point.

Benefits:

Your child's participation in the project will help the researchers understand the lives of people aged 9-15 years and how various technologies help or hinder their lives. Additionally, your child will be compensated with \$20.00 for their participation, regardless of whether they complete the study, or terminate their involvement early.

Extent of anonymity and confidentiality:

The results of this study will be kept strictly confidential. Except that the researcher may,

if you permit it below, use your contact information to request a follow-up interview.

Subject's responsibilities and Permission:

I voluntarily agree to my child's participation in this study, and I know of no reason my child cannot participate. I have read and understand the informed consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for my child's participation in this project. If my child participates, they may withdraw at any time without penalty.

- ☐ Yes, I agree and wish to participate
- ☐ No, I do not wish for my child to participate.

Child's first name

Child's last name(s)

child's email address

child's age

child's gender

- ☐ Male
- ☐ Female
- ☐ Other

child's phone number

How may we contact your child (from above)? We will contact them once daily with a link to the daily questionnaire.

- ☐ text the phone number provided above
- ☐ email the address provided above

May we contact you after your child has finished all of the daily questionnaires to request further details from your child?

- ☐ Yes
- ☐ No

A.3 Daily Diary

Each day of their 14-day enrollment period, participants were invited via their preferred communication medium (SMS or email) to respond to the following prompts. The free text questions were only asked for participants who responded affirmatively to the immediately preceding question.

Default Question Block

The Third Lab at Virginia Tech, particularly Professor Deborah Tatar, and graduate student Michael Stewart, thank you for your participation in our study. Through this research study, we are trying to better understand the daily life of 10-15 year-olds. We may publish the results of our research study. We hope that you will follow the link we send you to this survey each day for 14 days. Each day, the survey should take just a few (5-10) minutes. Your parent or guardian has agreed that you may participate in our study. You can choose not to answer questions, and if you wish, you can stop participating in this study at any time.

Participant ID

Have you kept in touch with your friends outside of school today (on the phone, using text messages, through apps, while playing online games together, or anything else)?

☐ Yes

☐ No

How and when did you keep in touch with your friends outside of school?

Click to write the question text

	Not at all	Occasionally	Frequently
How much did you use text, snapChat, online games, hangouts or any other technology tool to keep in contact?	☐	☐	☐

What did you talk about?

Have you listened to music today?

☐ Yes

☐ No

What music did you listen to?

Did you listen to any music with friends?

☐ Yes

☐ No

How did you share it?

Did your friends recommend any music to you or did you recommend any music to your friends?

☐ Yes

☐ No

How was the recommendation made?

Appendix B

Study 2: CoListen in the Lab

B.1 Study 2 IRB Approval



Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website <http://www.irb.vt.edu>

MEMORANDUM

DATE: July 15, 2015
TO: Deborah Gail Tatar, Michael Stewart
FROM: Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)
PROTOCOL TITLE: Colistening
IRB NUMBER: 14-709

Effective July 14, 2015, the Virginia Tech Institutional Review Board (IRB) Chair, David M Moore, approved the Amendment request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As: **Expedited, under 45 CFR 46.110 category(ies) 6,7**
Protocol Approval Date: **November 12, 2014**
Protocol Expiration Date: **November 11, 2015**
Continuing Review Due Date*: **October 28, 2015**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

B.2 Semi-structured Interview Questions

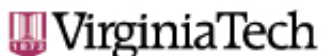
1. How did you end up here today?
2. Do you have siblings?
 - 2.1. Sibling Details
3. Do you keep in touch with friends outside of school?
 - 3.1. How?
 - 3.1. When?
 - 3.1. Why?
 - 3.1. What do you talk about?
4. How much do you use technology to keep in touch with friends?
5. Do you listen to music?
 - 5.1. What music?
 - 5.1. How? (what devices/services?)
6. Do you ever listen with friends? parents? siblings? other family members?
 - 6.1. How? (what devices/services?)
 - 6.1. Is it usually the same as what you listen to on your own?
7. Do you ever give or receive music recommendations to or from your friends?
 - 7.1. How? (what devices/services?)
8. Do you have your own phones/devices?
9. How did you meet your friend?
10. Do you spend much time together?
11. Are there times when you wouldn't want people to listen with you (do you have guilty pleasure music?)
12. Do you want to invite a friend to listen with you (rather than just them being able to listen with you as currently in Colisten)?

- 12.1. Would it be annoying to receive requests from your friends to colisten with them?
13. How would you choose which friend to listen with?
14. What do you see? What does it do?
15. What would you think about starting part-way through the song to which your friend is listening?
16. Do you have any rules or anything with parents about how much you can use devices?
17. Would you use Colisten?
18. How much?
19. With whom?
20. What kind of technology is available in your home for entertainment purposes and for communication purposes?
 - 20.1. clarification of types and specs
21. Do your parents have any rules about what music you can listen to? (parental control) (can this be 16.1)
22. How do you discover new music? (can this be 5.3)
23. What is your favorite artist (can this be 5.4)
24. Do you have any suggestions of improvements for Colisten?

Appendix C

Study 3: CoListen in the Wild

C.1 Study 3 IRB Approval



Office of Research Compliance
 Institutional Review Board
 North End Center, Suite 4120, Virginia Tech
 300 Turner Street NW
 Blacksburg, Virginia 24061
 540/231-4606 Fax 540/231-0959
 email irb@vt.edu
 website <http://www.irb.vt.edu>

MEMORANDUM

DATE: January 22, 2018
TO: Deborah Gail Tatar, Michael Clark Stewart
FROM: Virginia Tech Institutional Review Board (FWA00000572, expires January 29, 2021)
PROTOCOL TITLE: Colisten in the Wild
IRB NUMBER: 17-595

Effective January 22, 2018, the Virginia Tech Institutional Review Board (IRB) approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As: **Expedited, under 45 CFR 46.110 category(ies) 5,6,7**
 Protocol Approval Date: **January 22, 2018**
 Protocol Expiration Date: **January 21, 2019**
 Continuing Review Due Date*: **January 7, 2019**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
An equal opportunity, affirmative action institution

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

C.2 Current Music and Communication Practices

The first step in participating in the CoListen in the Wild research study was for participants to complete this pre-trial questionnaire. Next you will find the questionnaire as a participant would have seen it, with a few small exceptions:

1. The participants completed this in a web browser (mobile or desktop) on qualtrics.com.
2. Some questions were only displayed conditionally, based on the participant's response to a previous question.
3. For the (Inclusion of Other in the Self Scale [30]) venn-diagram-looking questions, the participant's entries from the earlier question about with whom they would join this research study would have been substituted where the below has (e.g.)

`${q://QID9/ChoiceTextEntryValue/1/1}`

Informed Consent for Participants in Research Projects Involving Human Subjects

Title of the Project: Colisten in the Wild

Principal Investigators:

Michael Stewart, and other investigators approved by the Institutional Review Board for this project.

Purpose of this Research/Project:

We are studying how people listen to music with each other, and how they feel about such experiences.

Procedures:

Participation in this study basically includes completing some questionnaires and listening to music using our app, Colisten. There are three phases to the study: Pre-trial, Trial, and Post-trial. Find the detailed explanation of participation by phase below.

Pre-trial

Prior to installing our app, you will complete a few questionnaires including demographic information, contact information, information about the communications technologies you use, and information about the friends with whom you will enroll in the study.

Trial

You will use our Colisten app as your primary music player for a period of two weeks. During this time, we will be collecting your music listening history from Spotify, we will record the actions you take in the Colisten app, and at the end of each day, we will prompt you to respond to a brief questionnaire about your experiences with the app.

Post-trial

We will ask you to complete a few final questionnaires to detail your experiences with the app and to indicate whether we may contact you to follow up about any details from the study.

Risks:

The risk is minimal. The only risk is that the participants do not enjoy the study, or find the questionnaires too time consuming.

Benefits:

You will benefit from getting to try a novel music-listening app. Additionally, your participation in the project will help the researcher study the effects of different kinds of

Contact and Demographics

What is your first name?

What is your last name?

At what email address may we contact you?

What phone number may we use to contact you via text message for the purposes of this study?

What are your month and year of birth (e.g. January 2004)?

What language did you speak in the home where you grew up?

Please enter the following information about 3 people who will join you in the study:
(please consider letting them know that you intend them to join you in this study so they
can anticipate the email we will send to them from tgm@vt.edu with subject: "Colisten
Research Study Invite")

	Name	Email	Relationship to you
Person 1			
Person 2			
Person 3			

How did you hear about this study?

Do you have daily access to an Apple iOS device (such as an iPhone) that you can use for
this study?

☐ Yes

☐ No

Who owns the device that you will use for this study?

What kind of device is it that you will use for this study (iPhone, iPod Touch, iPad, etc.)?

Keeping in touch

How do you usually keep in touch with family and friends?

How much do you use these technologies to communicate with your friends and family?

	Often	Most of the time	Sometimes	Rarely	Never
Text messaging (including SMS, SnapChat, iMessage, WhatsApp, Facebook Messenger, WeChat, Viber, GroupMe, Google Hangouts, or similar)	☐	☐	☐	☐	☐
Email	☐	☐	☐	☐	☐
Voice chat (including phone calls, FaceTime Audio, Skype Voice Call, WhatsApp Voice Calling, Facebook Voice Calling, Viber Voice Calling, Google Hangouts, or similar)	☐	☐	☐	☐	☐
Video chat (FaceTime, Skype, WhatsApp, Facebook Video Chat, Viber Video Call, Google Hangouts, or similar)	☐	☐	☐	☐	☐

How often would you say you are lonely?

- ☐ More often than daily
- ☐ Daily
- ☐ 4-6 times a week
- ☐ 2-3 times a week
- ☐ Once a week
- ☐ Once a month
- ☐ Rarely
- ☐ Never

What do you do when you are feeling lonely?

Would you be interested in feeling more “together” with your some of your friends or family?

- ☐ Yes
- ☐ No

Please indicate how close you feel to $\{q://QID9/ChoiceTextEntryValue/1/1\}$



Please indicate how close you feel to \${q://QID9/ChoiceTextEntryValue/2/1}

Seven Venn diagrams showing the relationship between 'Self' and 'Other' circles. The overlap between the circles increases from left to right, representing a scale from 'Not at all close' to 'Very close'.

Please indicate how close you feel to \${q://QID9/ChoiceTextEntryValue/3/1}

Seven Venn diagrams showing the relationship between 'Self' and 'Other' circles. The overlap between the circles increases from left to right, representing a scale from 'Not at all close' to 'Very close'.

Music

How often do you listen to music?

- ☐ Most of the day on most days
- ☐ Most of the day, but only on some days
- ☐ Some of the day on most days
- ☐ Some of the day, but only on some days
- ☐ Very little on most days
- ☐ Very little, but only on some days
- ☐ Almost never

What kind of music do you like to listen to?

What devices and services do you typically use to listen to music? (Do you use headphones, ear buds, or just speakers? Do you listen with an mp3 player, or other recorded media such as CDs or vinyl records? Do you use streaming services such as Amazon Music, Apple Music, Google Music, or Spotify?)

There are 2 different ways that you might login to Spotify:

1. using a spotify username and password
2. via Facebook

Please tell us who you are on Spotify by telling us either your Spotify user name (if you login via #1 above) or the email address you use to login to Facebook (if you login via #2 above).

How long have you been a Spotify user?

Do you ever listen to music with others?

- ☐ Yes
- ☐ No

With whom do you listen?

Do you usually listen to the same music with others that you would listen to by yourself?

☐ Yes

☐ No

How is what you listen to different when others are listening with you?

Do you ever give or receive music recommendations to/from your friends or family?

☐ Yes

☐ No

How do you make or receive those recommendations? (in conversation in person? while conversing over some technology like a text, voice, or video chat? Via some app that supports such recommendations?)

Are there ever times when you would not want people to know what music you are listening to?

☐ Yes

☐ No

When/under what circumstances might you prefer people not know what you're listening to? Which people?

What do you think it would be like to listen to music in sync with a friend or family member who is not present with you?

If you could listen to music with your family and friends (who are not present with you), how would you choose which friend to listen with?

What would you think about starting part-way through the song to which your friend is

listening so that you could listen in-sync with them?

Generally, what will your schedule be like over the next 2 months? (vacation for a week?
Working? Going to school? Is it much different than the rest of the year?)

C.3 Affective Benefits and Costs of Communications Technologies: SMS

After completing the first questionnaire and once their group was identified, I asked participants to complete two versions of the Affective Benefits and Costs of Communications Technologies instrument [118]. I asked them to complete this for both SMS and for their most-frequently used (non-SMS) ICT. Next you will find the questionnaire as a participant would have seen it for SMS, with a few small exceptions:

1. The participants completed this in a web browser (mobile or desktop) on qualtrics.com.
2. For many questions, the instrument asks that a participant include the name of someone with whom they would use the ICT in question. That name would have been substituted where the below has (e.g.)

`${q://QID1/ChoiceTextEntryValue}`

Default Question Block

What is your first and last name?

Please name a friend or family member with whom you communicate frequently via text messaging (SMS, or similar).

Communicating with \${q://QID1/ChoiceTextEntryValue} using SMS helps me tell how \${q://QID1/ChoiceTextEntryValue} is feeling that day.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ clearly
- ☐ as clearly as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using SMS helps me let \${q://QID1/ChoiceTextEntryValue} know how I am feeling.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ clearly

☐ as clearly as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using SMS helps me see how much \${q://QID1/ChoiceTextEntryValue} cares about me.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ clearly
- ☐ as clearly as possible

I feel that contact with me using SMS is engaging for \${q://QID1/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

I am excited about using SMS with \${q://QID1/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

I have fun with \${q://QID1/ChoiceTextEntryValue} while using SMS.

- ☐ not at all
- ☐ a little bit

- ☐ somewhat
- ☐ very much
- ☐ as much as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using SMS helps me feel closer to \${q://QID1/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

After we are done communicating, I keep thinking back to something \${q://QID1/ChoiceTextEntryValue} shared using SMS.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using SMS helps me feel more connected to \${q://QID1/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using SMS helps me provide \${q://QID1/ChoiceTextEntryValue} with social support.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

\${q://QID1/ChoiceTextEntryValue} makes me feel special in our contact using SMS.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

Communicating with me using SMS helps \${q://QID1/ChoiceTextEntryValue} be there for me when I need them.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using SMS when I am having a bad day helps me feel better.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat

- ☐ very much
- ☐ as much as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using SMS helps me feel less worried about something.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

I worry that \${q://QID1/ChoiceTextEntryValue} feels obligated to contact me using SMS.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

I have to talk to \${q://QID1/ChoiceTextEntryValue} using SMS even if I don't want to.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ a lot
- ☐ all the time

I feel guilty if I don't answer a contact \${q://QID1/ChoiceTextEntryValue} makes using SMS.

- ☐ not at all
- ☐ a little bit

- ☐ somewhat
- ☐ very guilty
- ☐ as guilty as possible

I have to answer when \${q://QID1/ChoiceTextEntryValue} tries to contact me using SMS even if I don't want to.

- ☐ feel no obligation to answer at all
- ☐ some obligation
- ☐ sort of have to answer
- ☐ should answer in most cases
- ☐ absolutely must answer

I feel sad when \${q://QID1/ChoiceTextEntryValue} isn't around when I try to contact \${q://QID1/ChoiceTextEntryValue} using SMS

- ☐ not at all
- ☐ a little sad
- ☐ somewhat sad
- ☐ very sad
- ☐ as sad as possible

I feel sad when \${q://QID1/ChoiceTextEntryValue} takes too long to respond when I try to contact \${q://QID1/ChoiceTextEntryValue} using SMS.

- ☐ not at all
- ☐ a little sad
- ☐ somewhat sad
- ☐ very sad
- ☐ as sad as possible

I worry that I am not meeting \${q://QID1/ChoiceTextEntryValue}'s expectations for our contact using SMS.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

I feel sad when \${q://QID1/ChoiceTextEntryValue} doesn't pay enough attention to me when we use SMS.

- ☐ not at all
- ☐ a little sad
- ☐ somewhat sad
- ☐ very sad
- ☐ as sad as possible

I worry that \${q://QID1/ChoiceTextEntryValue} might learn something using SMS that I want to keep secret.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

I worry about my privacy while \${q://QID1/ChoiceTextEntryValue} and I are using SMS together.

- ☐ not at all
- ☐ a little bit

- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

I worry that others may overhear or see something that \${q://QID1/ChoiceTextEntryValue} and I share using SMS.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

I worry that I am violating \${q://QID1/ChoiceTextEntryValue}'s privacy during our contact using SMS.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

C.4 Affective Benefits and Costs of Communications Technologies: Other ICT

After completing the first questionnaire and once their group was identified, I asked participants to complete two versions of the Affective Benefits and Costs of Communications Technologies instrument [118]. I asked them to complete this for both SMS and for their most-frequently used (non-SMS) ICT. Next you will find the questionnaire as a participant would have seen it for their most-frequently used (non-SMS) ICT, with a few small exceptions:

1. The participants completed this in a web browser (mobile or desktop) on qualtrics.com.
2. For many questions, the instrument has a parameter for either or both:
 - 2.1. the person that the participant communicates with frequently (with the subsequently defined ICT)
 - 2.2. the ICT the participant uses to communicate frequently (with the aforementioned person)

These parameters would have been substituted appropriately where the appendix here shows (e.g.)

`${q://QID1/ChoiceTextEntryValue}`

Default Question Block

What is your first and last name?

Please name a friend or family member with whom you communicate frequently via text messaging (SMS, or similar).

Please name a communication technology other than text/SMS that you use most frequently with friends/family.

Communicating with \${q://QID1/ChoiceTextEntryValue} using
\${q://QID2/ChoiceTextEntryValue} helps me tell how \${q://QID1/ChoiceTextEntryValue} is
feeling that day.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ clearly
- ☐ as clearly as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using
\${q://QID2/ChoiceTextEntryValue} helps me let \${q://QID1/ChoiceTextEntryValue} know
how I am feeling.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ clearly
- ☐ as clearly as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using
\${q://QID2/ChoiceTextEntryValue} helps me see how much
\${q://QID1/ChoiceTextEntryValue} cares about me.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ clearly
- ☐ as clearly as possible

I feel that contact with me using \${q://QID2/ChoiceTextEntryValue} is engaging for
\${q://QID1/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

I am excited about using \${q://QID2/ChoiceTextEntryValue} with
\${q://QID1/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

I have fun with \${q://QID1/ChoiceTextEntryValue} while using
\${q://QID2/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ some
- ☐ very much
- ☐ as much as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using
\${q://QID2/ChoiceTextEntryValue} helps me feel closer to
\${q://QID1/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

After we are done communicating, I keep thinking back to something
\${q://QID1/ChoiceTextEntryValue} shared using \${q://QID2/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much

☐ as much as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using
\${q://QID2/ChoiceTextEntryValue} helps me feel more connected to
\${q://QID1/ChoiceTextEntryValue}.

☐ not at all

☐ a little bit

☐ somewhat

☐ very much

☐ as much as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using
\${q://QID2/ChoiceTextEntryValue} helps me provide \${q://QID1/ChoiceTextEntryValue} with
social support.

☐ not at all

☐ a little bit

☐ somewhat

☐ very much

☐ as much as possible

\${q://QID1/ChoiceTextEntryValue} makes me feel special in our contact using
\${q://QID2/ChoiceTextEntryValue}.

☐ not at all

☐ a little bit

☐ somewhat

☐ very much

☐ as much as possible

Communicating with me using \${q://QID2/ChoiceTextEntryValue} helps
\${q://QID1/ChoiceTextEntryValue} be there for me when I need them.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ clearly
- ☐ as clearly as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using
\${q://QID2/ChoiceTextEntryValue} when I am having a bad day helps me feel better.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

Communicating with \${q://QID1/ChoiceTextEntryValue} using
\${q://QID2/ChoiceTextEntryValue} helps me feel less worried about something.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

I worry that \${q://QID1/ChoiceTextEntryValue} feels obligated to contact me using
\${q://QID2/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit

- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

I have to talk to \${q://QID1/ChoiceTextEntryValue} using \${q://QID2/ChoiceTextEntryValue} even if I don't want to.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ a lot
- ☐ all the time

I feel guilty if I don't answer a contact \${q://QID1/ChoiceTextEntryValue} makes using \${q://QID2/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very guilty
- ☐ as guilty as possible

I have to answer when \${q://QID1/ChoiceTextEntryValue} tries to contact me using \${q://QID2/ChoiceTextEntryValue} even if I don't want to.

- ☐ feel no obligation to answer at all
- ☐ some obligation
- ☐ sort of have to answer
- ☐ should answer in most cases
- ☐ absolutely must answer

I feel sad when \${q://QID1/ChoiceTextEntryValue} isn't around when I try to contact \${q://QID1/ChoiceTextEntryValue} using \${q://QID2/ChoiceTextEntryValue}

- ☐ not at all sad
- ☐ a little sad
- ☐ somewhat sad
- ☐ very sad
- ☐ as sad as possible

I feel sad when \${q://QID1/ChoiceTextEntryValue} takes too long to respond when I try to contact \${q://QID1/ChoiceTextEntryValue} using \${q://QID2/ChoiceTextEntryValue}.

- ☐ not at all sad
- ☐ a little sad
- ☐ somewhat sad
- ☐ very sad
- ☐ as sad as possible

I worry that I am not meeting \${q://QID1/ChoiceTextEntryValue}'s expectations for our contact using \${q://QID2/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

I feel sad when \${q://QID1/ChoiceTextEntryValue} doesn't pay enough attention to me when we use \${q://QID2/ChoiceTextEntryValue}

- ☐ not at all sad
- ☐ a little sad

- ☐ somewhat sad
- ☐ very sad
- ☐ as sad as possible

I worry that \${q://QID1/ChoiceTextEntryValue} might learn something using \${q://QID2/ChoiceTextEntryValue} that I want to keep secret.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

I worry about my privacy while \${q://QID1/ChoiceTextEntryValue} and I are using \${q://QID2/ChoiceTextEntryValue} together.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

I worry that others may overhear or see something that \${q://QID1/ChoiceTextEntryValue} and I share using \${q://QID2/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

I worry that I am violating \${q://QID1/ChoiceTextEntryValue}'s privacy during our contact using \${q://QID2/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

C.5 CoListen Daily Diary

During the 14-day trial at the end of each day (around 18:00 EDT), the participant would receive an SMS message prompting them to respond to the short prompts below, with a few small exceptions:

1. The participants completed this in a web browser (mobile or desktop) on qualtrics.com.
2. Some questions were displayed conditionally based on the participant's response to a prior question.

Default Question Block

Did you use Colisten with anyone today?

☐ Yes

☐ No

Why not?

How was the experience?

Where were you when you were using Colisten today?

What else were you doing when you were using Colisten today? (e.g. doing homework, exercising, eating, texting, etc.)

Did you feel more connected with or closer to your friends/family when you colistened with them?

Did colistening change how lonely you may have felt today? How?

C.6 CoListen Experience Post-Trial Questionnaire

After completing the 14-day trial, I emailed participants asking them to complete a questionnaire about their experiences during the 14-day trial. That questionnaire is reproduced below, with a few small exceptions:

1. The participants completed this in a web browser (mobile or desktop) on qualtrics.com.
2. Some questions were displayed conditionally based on the participant's response to a prior question.

Block 4

What's your name?

Block 3

Music listening

About how often did you choose to listen to music in Colisten compared to other options

Always listened using Colisten	Listened more often using Colisten	Listened to music in Colisten about half of the time in comparison with other means	Listened more often using means other than Colisten	Always listened using other means
☐	☐	☐	☐	☐

What other ways than using Colisten do you mostly listen to music? (please order them from most frequently used to least)

Please describe how you typically listen to music (e.g. "I set it and forget it. I put something on (e.g. "station", playlist, artist, album) and then just more or less let it play.", "I search for something I'd like to listen to, and maybe continue listening through a few related tracks, but soon perform the next search, relying more on my search activity than whole albums/artists or my own/others' playlists.")

Default Question Block

Technology

How did it go? Did Colisten work well?

Did you like Colisten?

Block 2

Relationships

Did you ever converse with your friends/family with whom you were colistening after the fact (about Colisten/colistening)?

Do you feel that having colistened with your friends and family has had any effect on your relationship with them?

☐ Yes

☐ No

Please enter the name of a person with whom you colistened and you feel that your relationship has been affected by colistening:

How would you say your relationship with \${q://QID7/ChoiceTextEntryValue} was affected?

In what ways did you interact with \${q://QID7/ChoiceTextEntryValue}, other than

colistening, during the study?

How "present" was \${q://QID7/ChoiceTextEntryValue} while you were colistening?

Did you ever feel obligated to continue listening or keep Colisten running longer than usual because of people listening to your music in Colisten?

- ☐ Yes
- ☐ No

Please share more with us about feeling obligated to continue with Colisten because of your colisteners.

Did you feel like you could stop listening with your Colisten "friend" whenever you wanted?

- ☐ Yes
- ☐ No

Please share more with us about your feeling that you could not stop listening to a "friend" in Colisten whenever you wanted.

Did you realize when you had friends listening with you?

- ☐ Yes
- ☐ No

How did it make you feel to co-listen with your friends?

Did co-listening change how much you may have missed your friend or family member?

- ☐ Yes
- ☐ No

How did co-listening affect how much you may have missed your friend or family member(s)?

Did co-listening change how alone you may have felt?

☐ Yes

☐ No

How did co-listening affect how alone you may have felt?

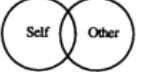
Please enter the names of the 3 people who were in your group for this study.

Person 1

Person 2

Person 3

Please indicate how close you feel to \${q://QID27/ChoiceTextEntryValue/1}

Click to write Choice 1	Click to write Choice 2	Click to write Choice 3	Click to write Choice 4	Click to write Choice 5	Click to write Choice 6	Click to write Choice 7
						
☐	☐	☐	☐	☐	☐	☐

Please indicate how close you feel to \${q://QID27/ChoiceTextEntryValue/2}

Click to write Choice 1	Click to write Choice 2	Click to write Choice 3	Click to write Choice 4	Click to write Choice 5	Click to write Choice 6	Click to write Choice 7
						
☐	☐	☐	☐	☐	☐	☐

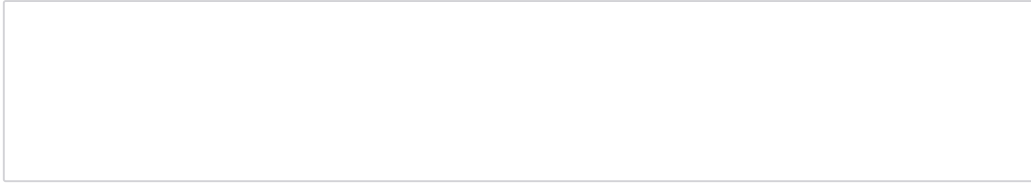
Please indicate how close you feel to \${q://QID27/ChoiceTextEntryValue/3}

Click to write Choice 1	Click to write Choice 2	Click to write Choice 3	Click to write Choice 4	Click to write Choice 5	Click to write Choice 6	Click to write Choice 7
						
☐	☐	☐	☐	☐	☐	☐

Block 1

Future of Colisten

When (if ever) might you rather just share a playlist with a friend or family member (rather than actually co-listening with them)?



What improvements or changes would you like to see in future versions of Colisten?



Would you like to continue using Colisten now that the trial for this study has ended?

☐ Yes

☐ No

C.7 Affective Benefits and Costs of Communications Technologies: CoListen

After completing the 14-day trial, I asked participants to complete a final version of the Affective Benefits and Costs of Communications Technologies instrument [118]. I asked them to complete this for CoListen as an ICT. Next you will find the questionnaire as a participant would have seen it, with a few small exceptions:

1. The participants completed this in a web browser (mobile or desktop) on qualtrics.com.
2. For many questions, the instrument asks that a participant include the name of someone with whom they would use CoListen. That name would have been substituted where the below has (e.g.)

`${q://QID1/ChoiceTextEntryValue}`

Default Question Block

What is your first and last name?

Please name a friend or family member with whom you listened with or wished to listen with most frequently via the Colisten app.

Listening to music with \${q://QID1/ChoiceTextEntryValue} using Colisten helps me tell how \${q://QID1/ChoiceTextEntryValue} is feeling that day.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ clearly
- ☐ as clearly as possible

Listening to music with \${q://QID1/ChoiceTextEntryValue} using Colisten helps me let \${q://QID1/ChoiceTextEntryValue} know how I am feeling.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ clearly

☐ as clearly as possible

Listening to music with \${q://QID1/ChoiceTextEntryValue} using Colisten helps me see how much \${q://QID1/ChoiceTextEntryValue} cares about me.

☐ not at all

☐ a little bit

☐ somewhat

☐ clearly

☐ as clearly as possible

I feel that contact with me using Colisten is engaging for \${q://QID1/ChoiceTextEntryValue}

☐ not at all

☐ a little bit

☐ somewhat

☐ very much

☐ as much as possible

I am excited about using Colisten with \${q://QID1/ChoiceTextEntryValue}.

☐ not at all

☐ a little bit

☐ somewhat

☐ very much

☐ as much as possible

I have fun with \${q://QID1/ChoiceTextEntryValue} while using Colisten.

☐ not at all

☐ a little bit

- ☐ somewhat
- ☐ very much
- ☐ as much as possible

Listening to music with \${q://QID1/ChoiceTextEntryValue} using Colisten helps me feel closer to \${q://QID1/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

After we are done listening to music, I keep thinking back to something \${q://QID1/ChoiceTextEntryValue} shared using Colisten.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

Listening to music with \${q://QID1/ChoiceTextEntryValue} using Colisten helps me feel more connected to \${q://QID1/ChoiceTextEntryValue}.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

Listening to music with \${q://QID1/ChoiceTextEntryValue} using Colisten helps me provide \${q://QID1/ChoiceTextEntryValue} with social support.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

\${q://QID1/ChoiceTextEntryValue} makes me feel special in our contact using Colisten.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

Listening to music with me using Colisten helps \${q://QID1/ChoiceTextEntryValue} be there for me when I need them.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

Listening to music with \${q://QID1/ChoiceTextEntryValue} using Colisten when I am having a bad day helps me feel better.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat

- ☐ very much
- ☐ as much as possible

Listening to music with \${q://QID1/ChoiceTextEntryValue} using Colisten helps me feel less worried about something.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very much
- ☐ as much as possible

I worry that \${q://QID1/ChoiceTextEntryValue} feels obligated to listen to music with me using Colisten.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

I have to listen to music with \${q://QID1/ChoiceTextEntryValue} using Colisten even if I don't want to.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ a lot
- ☐ all the time

I feel guilty if I don't listen to music with \${q://QID1/ChoiceTextEntryValue} using Colisten.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ very guilty
- ☐ as guilty as possible

I feel sad when \${q://QID1/ChoiceTextEntryValue} isn't around when I try to listen to music with \${q://QID1/ChoiceTextEntryValue} using Colisten

- ☐ not at all
- ☐ a little sad
- ☐ somewhat sad
- ☐ very sad
- ☐ as sad as possible

I worry that I am not meeting \${q://QID1/ChoiceTextEntryValue}'s expectations for our contact using Colisten.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

I feel sad when \${q://QID1/ChoiceTextEntryValue} doesn't pay enough attention to me when we use Colisten

- ☐ not at all
- ☐ a little sad
- ☐ somewhat sad
- ☐ very sad

☐ as sad as possible

I worry that \${q://QID1/ChoiceTextEntryValue} might learn something using Colisten that I want to keep secret.

☐ not at all

☐ a little bit

☐ somewhat

☐ worry a lot

☐ worry constantly

I worry about my privacy while \${q://QID1/ChoiceTextEntryValue} and I are using Colisten together.

☐ not at all

☐ a little bit

☐ somewhat

☐ worry a lot

☐ worry constantly

I worry that others may overhear or see something that \${q://QID1/ChoiceTextEntryValue} and I share using Colisten.

☐ not at all

☐ a little bit

☐ somewhat

☐ worry a lot

☐ worry constantly

I worry that I am violating \${q://QID1/ChoiceTextEntryValue}'s privacy during our contact using Colisten.

- ☐ not at all
- ☐ a little bit
- ☐ somewhat
- ☐ worry a lot
- ☐ worry constantly

C.8 CoListen Post-Trial Semi-structured Interview Protocol

In the email where I asked participants who had completed their 14-day trial to complete the [CoListen Experience Post-Trial Questionnaire](#) and [ABCCT for CoListen](#), I also asked them to contact me with their availability for a telephone interview. This was a semi-structured interview with the following protocol.

CoListen Research Study Interview Protocol

Overview

Following participants' two weeks of using our CoListen application and responding approximately daily to short diary prompts, we would like to follow up with some of them and video (and audio) record the interviews to further our data analysis. We will use a semi-structured interview, and as such we cannot list precisely the questions that we will ask. Of course, we can share the guidelines that we have planned for the interview questions/trajectory.

Interview Guidelines

The interview will start out more broad and open asking about their experiences and asking about any technical issues the participants may have experienced. With the potential technical issues out of the way, we will start to ask participants specifics about the context of their use of CoListen. For example, we may ask something like,

"Can you recall a time that you succeeded in colistening? Where were you and what were you doing? Do you have any idea what your 'friend' was up to when colistening with you?"

We would be interested in knowing other details about the experience that the participants may recall.

"Can you recall a time that you succeeded in colistening? What song(s) do you remember listening to?"

As our application supports a participant's ability to listen to their own existing music, we are interested to know how often the participants chose to listen using our application rather than others.

Some other possible topics, expressed as possible questions to participants:

- Did you ever talk about having colistened later with the person with whom you listened? With someone else? What'd y'all have to say?
- Did you ever use other technology/ICTs to coordinate co-listening?
- Would you describe your usual music listening behavior for us (Set it and forget it? use playlists? Search listen, get tired of it, repeat)
- Were you ever surprised to learn that people were colistening with you?
- Did you already connect with these folks in spotify prior to our study?