Meerkat and Periscope: I Stream, You Stream, Apps Stream for Live Streams

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ABSTRACT

We conducted a mixed methods study of the use of the Meerkat and Periscope apps for live streaming video and audio broadcasts from a mobile device. We crowdsourced a task to describe the content, setting, and other characteristics of 767 live streams. We also interviewed 20 frequent streamers to explore their motivations and experiences. Together, the data provide a snapshot of early live streaming use practices. We found a diverse range of activities broadcast, which interviewees said were used to build their personal brand. They described live streaming as providing an authentic, unedited view into their lives. They liked how the interaction with viewers shaped the content of their stream. We found some evidence for multiple live streams from the same event, which represent an opportunity for multiple perspectives on events of shared public interest.

Author Keywords

Live streaming; Meerkat; Periscope; mobile video; shared experiences.

ACM Classification Keywords

H.4.3 [Information Systems Applications]:
Communications Applications – computer conferencing, teleconferencing, and videoconferencing.

INTRODUCTION

The recent popularity of the mobile live streaming apps Periscope (http://www.periscope.tv/) and Meerkat (http://meerkatapp.co/) has attracted a lot of users, media attention, and funding [16]. While live streaming is not a new concept [15], these two apps have become popular by leveraging mature social networking (Twitter) and mobile platforms. Both apps, enable immediate live broadcasting of video and audio from a mobile smartphone, to whomever wants to tune in. A live stream can be started in a few taps and announced with a tweet to the Twitter social network. Both apps require a Twitter handle as the login, and the

integration with Twitter expands the reach of these live stream notifications for attracting an impromptu audience. The social network within each app also propagates notifications when someone they follow starts a live stream. A viewer can also browse the list of all current live streams to discover something of interest to watch in the moment.

Upon selecting a live stream, viewers can share text comments and give positive feedback (hearts) to the stream. That feedback, along with metadata about the number of viewers and their Twitter handles, appear as part of the live stream for all to see. Figure 1 shows a screenshot of viewing a live stream in both Meerkat and Periscope at the time of this study (April 2015). Throughout this paper, we will focus on live streaming features that are common to both apps despite some differences in their user experiences.

Figure 1. Viewing a live stream in Meerkat (left) and Periscope (right), showing entering a text comment and getting hearts.

In light of the growing trend of live streaming, we conducted a mixed methods study to explore research questions about how early adopters were using these media and social engagements that these platforms enable. In particular, we explored: 1) what live streamed content is being viewed, 2) the goals of people live streaming, and 3) the nature of interaction among viewers and streamers.

After reviewing related work, we describe the data collection for our study, which combined crowdsourced

tasks for describing the content of live streams and interviews with frequent streamers on both apps. We then report on live streams, streamers, interaction with viewers, and clusters of multiple live streams from the same event. We conclude with reflections on this current snapshot of emergent live streaming activity and opportunities for future research.

RELATED WORK

Prior work has examined mobile live video calling (synchronous, symmetric interaction), large-scale video sharing (asynchronous video viewing), and specialized streaming services (which did not become mainstream).

Mobile Live Video Calling

While there has been a wealth of research on video communication [8], recent research has focused on how video calling has leveraged mobile devices to go beyond talking heads to sharing activities. Brubaker et al. [1] found that close social contacts explored using video to share a diverse range of activities (e.g., watching movies together, cooking with mom, remote baby-sitting). While most studies focused on video calls between pairs of people, clients such as Google+ Hangouts have enabled calls of up to ten people, including mobile clients, to participate in a video call [3].

Clients for video calling that run on mobile smartphones have enabled using video outside the home to share activities wherever they occur. O'Hara et al. [18] found that over half of video calls made on mobile phones occurred outside home or work settings. Inkpen et al. [14] looked at how a mobile video prototype enabled sharing a variety of family events, including outdoor sporting events. Procyk et al. [21] developed a video streaming technology probe that enabled shared geocaching over distance. They found that video streaming such a closely coordinated shared activity created a very strong connection between remote people.

While mobile video calling has naturally focused on live video connections among pairs or small groups of people who know each other well, Tian et al. [25] studied a mobile video prototype that randomly connected strangers. They found that video chat sessions among strangers tended to be very short and concentrated among heavy users. One focus of their work identified that misbehavior in these video chats was negatively correlated with showing a face within the video and with group video sessions.

Live streaming apps extend video connections to an audience who is largely unknown to the streamer and each other, since current live streams can be discovered by anyone. Also, the interface is asymmetrical in that streamers stream audio and video, but viewers communicate only through text and hearts. These distinct characteristics of live streaming apps led us to explore the nature and motivations of people who stream over these services, what kinds of activity are shared, and what social interactions occur.

Large-scale Video Sharing

YouTube is a large-scale video sharing service that offers asynchronous viewing of videos with user feedback through comments and opportunities for social connection through channels and following. Ding et al. [5] crawled the related video graph in YouTube to log 44.8 million unique uploaders. They found that the most active uploaders (top 20%) contributed 73% of the videos, which accounted for 97% of the views. Thus, a small portion of the user population generates the bulk of the content viewed in YouTube. Surprisingly, 63% of the most frequent uploaders were largely uploading copied content originally distributed outside of YouTube, rather than user generated content. Thus, much of YouTube seems to be about excerpting or resharing video material from other sources, rather than new, user generated content to "Broadcast Yourself."

Siersdorfer et al. [24] analyzed commenting behavior in YouTube and found that most of the comments were concentrated on a small set of popular videos. Only 1% of videos got more than ten comments in a Zipf's law distribution that is typical of many large-scale community contribution systems. Chatzopoulou et al. [2] found that, on average, a video on YouTube receives a comment, a rating, or is added to a favorite list once for every 400 views. These studies document the sparseness of user engagement activities on videos within YouTube.

Tsou et al. [26] compared comments on TED Talk videos on the TED website and on YouTube. They found that on the TED website, commenters were more likely to engage with the talk content compared to YouTube, where they tended to discuss the characteristics of the presenter and engage with prior commenters. Personal insults were a small portion of the comments, but more likely on YouTube (5.7%) than on the TED site (less than 1%). Thus, different platforms for sharing identical video content can engender different kinds of engagement with the community at large.

Large-scale video sharing sites such as YouTube store huge amounts of diverse video recordings, yet most contributions come from a fractional subset of active uploaders, and most views are concentrated on the most popular videos. While it is possible to craft a conversational experience through YouTube [12, 13], most of the social interaction is limited to text comments, which only a fraction of YouTube videos are able to elicit. Despite the engaging nature of video as a medium, asynchronous viewing through YouTube engenders only a limited amount of social engagement around the videos within its platform. We wanted to explore how the 'liveness', ephemerality, and interaction of large-scale live streaming would compare and contrast with the engagement around viewing recorded videos.

Specialized Video Streaming Services

While there have been live video streaming services that predated Meerkat and Periscope, they were more specialized in their user community or limited by a lack of integration with an established social network. One popular niche

focused on computer gaming, through services such as Twitch.tv. Twitch offers a similar affordance of broadcasting live video and audio (typically a screen capture of an online game with a video of the player embedded) along with a text backchannel with all the viewers. A social network within Twitch affords following channels of interest and getting notifications when broadcasts go live.

Pires & Simon [20] did an early study of YouTube Live and Twitch as emerging live streaming services. YouTube Live is functionally similar to Twitch, but with more general content and a variety of different channels. Their log data found that both services offered a choice of live content at all hours of the day, although they did exhibit diurnal and weekly patterns. Zhang & Liu [30] also did a logging study on Twitch and found that views were heavily skewed to the most popular fraction of broadcasters. They found that 30% of Twitch sessions lasted 60-120 minutes, which appeared to be largely driven by the length of the shared gaming activity.

Hamilton et al. [11] examined Twitch to better understand the development of community around video game streaming and viewing. While they found that the main motivation for starting to view Twitch streams was to learn more about a specific game, it usually developed into an interest in social interaction and forming community. They also comment on the affordance of combining the *hot media* of video, which compellingly shows surprises and reactions, with the *cool media* of text chat, which is a medium with very limited expressiveness but allows large-scale participation. Weisz et al. [28] had earlier studied the combination of chatting over text while watching video together, and found that chatting improved the social experience, despite the challenges of distraction and dividing attention.

Shamma et al. [23] studied how DJs used live streaming to host music sessions. Their video streaming site enabled the DJ to watch up to four listeners over video for cues of reaction and engagement, which helped refine their DJ performance. Their specialized video streaming site enabled performers to develop close connections with their audience.

Dougherty [6] studied the use of Qik, a mobile live streaming service that offered video broadcast and text chat feedback integrated with social networking. While the study focused on using Qik for civic content (journalistic, activistic, political, educational), she reported on overall usage patterns based on coding 1000 videos and interviewing seven producers. She found that 71% of her sample were produced by males and 11% qualified as having civic value. We compare other data points from her study with our dataset for this new wave of live streaming with Meerkat and Periscope.

Juhlin et al. [15] analyzed how people used an earlier generation of mobile streaming services, such as Qik, Kyte, and Bambuser. They found that the technology at the time was too immature for producing polished live video from a mobile phone and finding broadcasts of interest. Meerkat and Periscope leverage a more mature mobile platform, with

devices that offer higher quality image and audio capture and a network that affords higher bandwidth for streaming them.

Advances in mobile technology enable Meerkat and Periscope to offer effective live streaming from a smartphone, unlike previous services that were oriented around computers, or had unpolished mobile video. This design choice gives maximum flexibility about the kinds of activities and settings that can be live streamed. Integration with the Twitter social network for announcing impromptu live streams affords attracting an audience for them. We wanted to explore how the mobile, social, and interactive affordances of Meerkat and Periscope were utilized in the activities broadcast and viewed in live streaming.

DATA COLLECTION

We designed a multi-method study to get a rich snapshot of live streaming activity during this emergent, early adopter stage of the apps: We crowdsourced a task to ask people to characterize the content of live streams in Meerkat and Periscope, and then we interviewed frequent streamers to get their perspectives on why they stream. We collected data from April to May, 2015, roughly two months after Meerkat and one month after Periscope were launched.

Crowdsourced Coding of Live Streams

We used crowdsourcing to characterize activities in the live streams. We asked Amazon Mechanical Turk crowdworkers to select one livestream to view for at least two minutes and describe the activity, the setting, and the people involved. They completed a survey that was a mix of open-ended and multiple choice survey questions to expedite data collection and analysis. The choices were determined by first piloting the task with open-ended questions for over 50 instances and categorizing those responses into multiple choice selections (with the option to write in for "Other"). Figures 2-6 include the text of the survey questions and summarize the responses. We required that Turkers have a 99% approval rating, and detected inappropriate responses through inconsistent multiple choice responses (which led to not approving one crowdsource task response).

For each of Meerkat and Periscope, MTurk tasks were issued at different times of the day and different days of the week to distribute the sampling over time. Based on live streaming usage statistics that were available at the time, we achieved about a 1% sample of live streams over seven days of data collection. We time released more MTurk tasks for Periscope than Meerkat, based on their higher volume of live streams. There was wide variation in the time to complete the task (many needed to install the app first), but the average compensation rate was about $15/hour. We collected 767 valid survey responses (535 Periscope, 232 Meerkat).

Interviews

We also conducted 20 semi-structured interviews of people identified in lists of popular streamers (e.g., the Meerkat leaderboard, http://meerkatstats.com/) and our crowdsource data as frequent streamers in Meerkat or Periscope. We

recruited recurring streamers mentioned in the surveys by collecting their Twitter ID, looking up their profile in Twitter to find contact info, and requesting an interview over email.

Our interview over Skype lasted about 30-minutes (median 31.1) and asked about their motivations for live streaming, what triggered them to start a stream, their interactions with viewers, what live streams they viewed, and other details about their live streaming experience. We interviewed 13 male and 7 female participants ranging from 18-62 years old (median 35) from around the world, including two from Australia, three from Europe, one from Canada, and the rest from the United States. Four of the Meerkat streamers we interviewed were in the top 100 leaderboard at the time. We refer to these interview participants by number and whether they use Meerkat (M), Periscope (P) or both (MP) to live stream. We again sought more Periscope users than Meerkat user, resulting in 12 participants who only used Periscope, 1 who only used Meerkat, and 7 who used both to live stream. The interviews were recorded and transcribed, which were reviewed, open coded, and iteratively clustered into recurring themes using a grounded theory approach [10].

RESULTS

We report on our results in terms of the *streams* that were viewed, the *streamers* who were broadcasting them, and the *viewers and interactions* within a stream. Since our interviews identified the opportunity for multiple live streams at the same event, we also report on *clusters of multiple live streams*. We synthesize results across our data collection methods. While we mostly treat Meerkat and Periscope as comparable live streaming services, we note results that might be related to differences between them.

Streams Viewed

Since the MTurk workers were free to select any live stream to view within each platform, our data represent what live streams were viewed among those that were available at the time. The 767 crowdsource responses described live streams from 489 unique streamer IDs. This means that we got multiple responses either from the same broadcast at the same time, or from a recurring live streamer on a different broadcast. We cannot identify responses concerning the same live stream, but take this to be a measure of what people would choose to watch among the live streams available.

We got 17 responses from viewing the most popular streamer in our dataset, and the eight most popular streamers (~1% of our sample) accounted for over 11% of the responses. There were 377 streamers who only got one crowdsource response. Since MTurk workers were allowed to freely select a live stream that was of interest to them, our data show that popularity of streams is not evenly distributed. Just as Ding et al. [5] found that the bulk of content contributed and viewed in YouTube was concentrated in the top fraction of popular contributors and videos, we might expect that viewing streams is concentrated in a smaller set of popular and frequent streamers, although viewing what happens to be available at the time may introduce more variety.
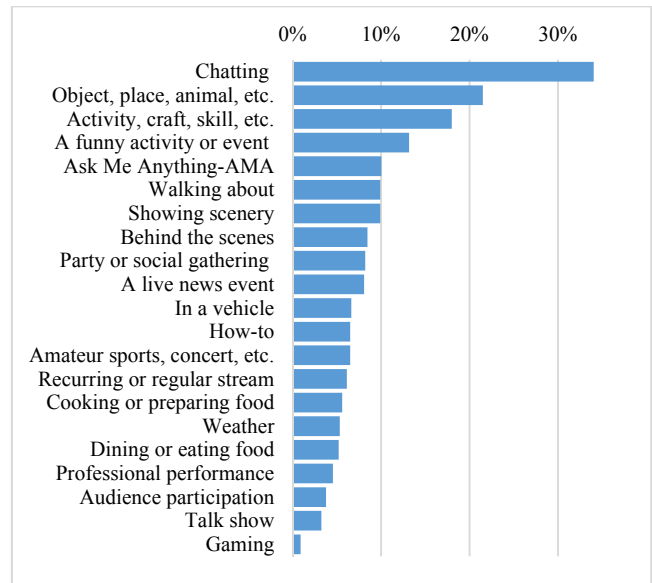
Figure 2: Crowdsourced responses to, "Select from the following to describe the category of activity being shown in the live stream (Choose all that apply)."

Figure 2 shows the crowdsourced coding of live streams, illustrating the wide range of activities that were viewed. The largest proportion of live streams included an asymmetric form of chatting where the streamer verbally responded to text comments submitted by the viewers. Many of the other live streams used video to show objects, places, activities, demonstrations, events, etc. Many of these activities (e.g., walking about, showing scenery, events) leveraged the mobile devices used for live streaming. While many of our categories overlap with those of Juhlin et al. [15], they did not observe general chatting. Since chatting, does not rely on the mobile nature of a smartphone, it suggests that these live stream apps have remediated an activity that could occur on a desktop computer by making it more convenient in a mobile context. The 11% of live streams that Dougherty coded of civic value [6] would fall in the live news, amateur, and professional events in our dataset.
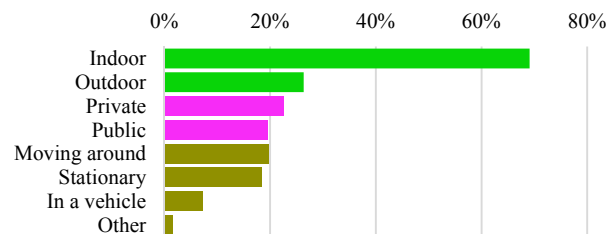
Figure 3: Crowdsourced responses to, "What is the setting for the activity using the following tags (Choose all that apply)."

Figure 3 shows the settings in which the activities took place, with more streams described as indoor (n=530), than outdoors (n=202), X^2=147, *p<.001*. Comparable amounts of live streams were done in private places (n=173) as well as public places (n=151), X^2=1.5, *p=.222*. The number of

live streams that involved mobility (n=156), including being in a vehicle, was similar to those that were stationary (n=142), X^2=0.66, $p=.417$.
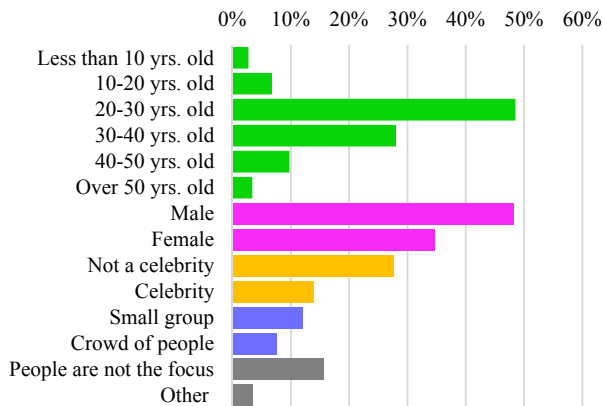
Figure 4: Crowdsourced responses to, "Describe the person or people that are the main focus in the video of the live stream, using the following tags (Choose all that apply)."

Figure 4 characterizes the people that appeared in the live streams. 49% of the streams had people thought to be in their 20's and 30's. More streams had people identified as males (48%) compared to females (35%), $X^2 = 17$, $p=<.001$, although gender was more balanced than the 71% male streamers found by Dougherty [6]. While live streaming by celebrities tends to get more media attention, our data show that there were about twice as many live streams viewed from people not considered a celebrity, $X^2 = 34.6$, $p<.001$.

In the interviews, we asked what prompted people to initiate a live stream. Most valued the spontaneous and impromptu nature of being able to start a stream then immediately engage with viewers.

Fun, spontaneous, interesting, something I'd like to share with other people… for no other reason than to just entertain them. MP5

I think the brilliance of Periscope is that it's spontaneous and because it's so well integrated with Twitter you just find that people can still find you anyway. MP8

…the beauty of Periscope is the serendipitous sort of – you never know what you'll catch. I almost caught a guy getting hit by a truck yesterday! P17

It's immediate… it's more personal because it's at that moment, you record that moment and that moment you can review that moment for only 24 hours. P14

However, ten of the 20 interviewees regularly pre-announced or scheduled their live streams, and one more indicated thinking about providing advanced notice of their broadcasts. Especially among the high volume streamers that we interviewed who were interested in growing their viewer base, their experiences suggest the value of forecasting live streams in advance.

Streamers
In the interviews, we asked what the streamers hoped to gain from live streaming. We point out that since we recruited frequent streamers to interview, these responses may be biased towards those who are investing considerable effort in their live streaming. The most common response was characterized as *personal branding*, establishing an online identity that attracts followers by offering them some value.

It's all about broadcasting for brand. P4.

…creating my own voice, my who am I, what do I want to communicate, what does my audience respond to… P17

I'm going to tell you the truth. I do want to create a fan base. P20

Many combined work-related goals with their live streaming. Many talked about making business contacts, driving traffic towards their monetized online resources, and P19 spoke of getting a job through her live streaming contacts. Based on viewing her live stream of a fashion event, a viewer paid her to live stream at an upcoming fashion event.

The interviews further illustrated how the streamers found the *interaction* in live streaming to be an engaging way of developing their personal brand.

People were saying whether I should get it or not or whether they liked the outfit. It was people from all over the world. P4

What do people want to hear from [me]? This is survey data from the gods! MP12

At first... I wasn't too impressed, but then someone on the thing said, "Hey, I just saw you walk by the Samsung booth, can you turn around and go back over to the Samsung booth?" So I pivoted and turned and I immediately thought, "Wow, I'm able now to let my audience kind of have input into what I'm doing!" MP6

You have the crowd participating in what you're doing and they can actually change the history of what's happening. MP10

It is this immediate interaction with viewers that can affect the ensuing content of the live stream that offers a higher level of engagement than viewing videos asynchronously, such as with YouTube. Several described the reactions of their live streaming audience as valuable input to their work, such as trying out topics for their radio show (P16) or discussing ideas for an upcoming book (P20).

Others cited dealing with live video as a *valuable life skill* that would help them in their careers.

...it is live, it is in real time. You are opening yourself up to anything (laughs) …just hit record and start talking to the world without any preparation or any thought. P13

...also it helps me articulate and communicate my thoughts… force yourself to put words into something. So that's been a huge benefit. MP10

Puts me on the spot… that's a skill that I'm going to need to have... P7

I'm a professional communicator... I want to be good with people. I want to be able to handle people in different situations... I feel as though there's value in that from Periscope. P18

Live streaming enables interacting with a very diverse audience, and many people found that the experience gained from managing whatever transpired from those live encounters was a useful life skill.

Streamers also mentioned a recurring theme about how live streaming was an *authentic* medium. MP6 shared how doing live streams that were both work-related and for entertainment allowed viewers a "…true, authentic me element is really all through my same [Twitter] handle".

Like I am into beauty. I am into technology. I am into fitness and health and that's just who I am, into all these different things. P7

...without editing and without Photoshop, without Auto-Tune. They can see that I'm a real artist and they see what life is really like… being an independent musician. MP8

This unedited and authentic nature of live streaming contrasts with the more curated representation of self exhibited in social media such as Facebook [32]. Rather than being able to selectively manage your image by choosing what to share on social media, our interviews found that at least frequent live streamers appreciated its more transparent and authentic nature. Streamers could curate the context of their broadcasts, and some mentioned planning ahead about when in their day it would be interesting to live stream. However, there was considerable unpredictability about what could unfold during the live broadcast, revealing the streamer's authentic reactions.

The crowdsourced coding of live streams showed a range of streamers' responsiveness to their viewers' comments, as shown in Figure 5. We cross-referenced these responses with the live stream activity (as categorized in Figure 3), and found that the highest percentage of streamers who actively or sometimes responded occurred in chats, ask me anything, and cooking sessions, which all depended on responding to users' comments. Conversely, streaming a professional or amateur event had lower percentages of responsive streamers, since it was hard to verbally respond to viewer comments without disturbing the event. In most of the other kinds of events, streamers were rated as being

responsive over 50% of the time. These data exhibit a likelihood that streamers interactively respond to comments raised in live streams, demonstrating a higher level of engagement with the viewing audience than in YouTube.
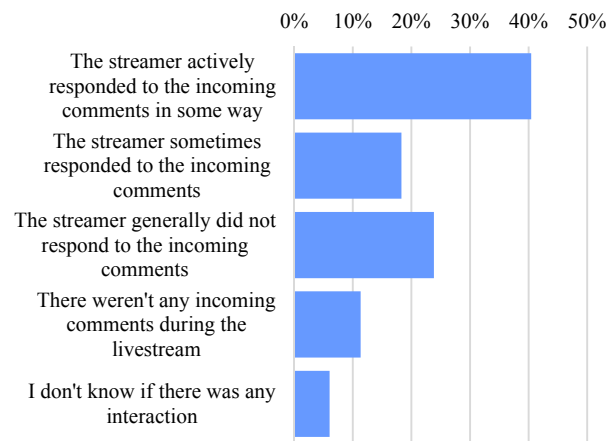
Figure 5: Crowdsourced responses to, "What kind of interaction is happening between the person streaming and the remote audience through the incoming texts?"

During the interviews, we asked streamers how they thought people chose what live streams to view, based on their experience both as a streamer and viewer. Four of them (P3, P4, MP10, and P19) said that they really do not view others' streams. MP10 and P19 said that they were so busy streaming that they did not really have the time to view live streams, and P4 simply remarked, "No, I'm so bad about that. I'm like a really selfish social media person".

Those who viewed others' live streams offered a couple reasons for what they chose to view. Explicitly following others and responding to notifications when a stream started was a common mechanism. Both apps streamlined the process from getting a notification to viewing a live stream to just one click. Several mentioned viewing others' live streams just to support them by adding views and comments to their metrics, more so than interest in the content. This practice exhibits community-building work, at least among the high volume streamers that we interviewed.

Most of the interviewees also mentioned browsing among the list of currently available livestreams to find content of personal interest to them. While those interests were highly diverse (e.g., technology, different cultures, behind the scenes at shows, what a celebrity eats), many people mentioned the importance of an effective title, both in choosing what to view and to attract views as a streamer.

...it's literally, if the headline captivates me, I'll have a look and if it doesn't, won't. P16

They like the title, and probably they click. That's why I try to put an interesting word when I write the title in my Periscope. P19

I was playing around with the titles… the more simple title seems to get the most traction, at least at the start... P7

We asked our interview participants whether they blocked anyone due to inappropriate behavior. Both services offer a mechanism for reporting inappropriate streams, and Periscope provides a button in the interface for blocking a viewer. While six users reported blocking someone, twelve reported that they never had. Most found it effective to just ignore inappropriate comments, as they soon disappeared from view. Even those who had not blocked anyone recognized that it was a potential problem, especially for women who seemed more frequently targeted by harassment. The interviews described some social behaviors for managing appropriate behavior in live streams. M11 reported that she watches what some supermodels live stream "almost as a babysitter... just to make sure Meerkat stays clean". P18 reported blocking a viewer of someone else's broadcast, which does community work by removing that viewer from the broadcast and sending a signal of being inappropriate.

What I found interesting is that a lot of times [the viewers] come to my defense, and they'll immediately recognize when someone is not sincere. P3

Even though Meerkat does not have a blocking mechanism in the interface, a "social shaming" hashtag has come in to use where people tweet out a #911MK hashtag along with the Twitter handles of trolls to alert the Meerkat team [7]. Even though the streamers and viewers do not necessarily know each other, we found evidence for social mechanisms for managing appropriate behavior in live streams. Our observations build on those of Tian et al. [25], who found that sharing video in a group context naturally added some safeguards against inappropriate content.

Clusters of Multiple Live Streams
In our first interview, P1 described how watching 3-4 different live streams of a major championship boxing fight in Las Vegas was "like being in the arena". Furthermore, while his wife was not interested in the fight, she liked seeing the celebrities in attendance, which some of the live streamers focused on. This story demonstrated an interesting opportunity to get different perspectives from multiple live streamers at the same event.

One question in our survey of crowdsourced coding of live streams asked specifically if events were being captured (although not necessarily live streamed) by multiple people (see Figure 6). Responses indicated that viewers could visually see others capturing the event on their phone in 5% of the live streams viewed, and was considered likely in another 12%. Cross referencing the events where others capturing the event were seen or seemed likely with the categories from Figure 2, we found that the most likely events with multiple perspectives were: a live news event (22%), a funny activity or event (19%), a party or social

gathering (19%) and chatting (19%). Amateur and professional events account for 16% and 14% of those responses respectively. Many of these kinds of events qualify for the civic value events that Dougherty studied [6]. Together these data suggest potential opportunities for clusters of live streams and other social media that reflect public interest and provide civic value. It would be interesting for Meerkat and Periscope to analyze (or make the data available for analysis) how much current live streaming occurs in clusters around the same event.
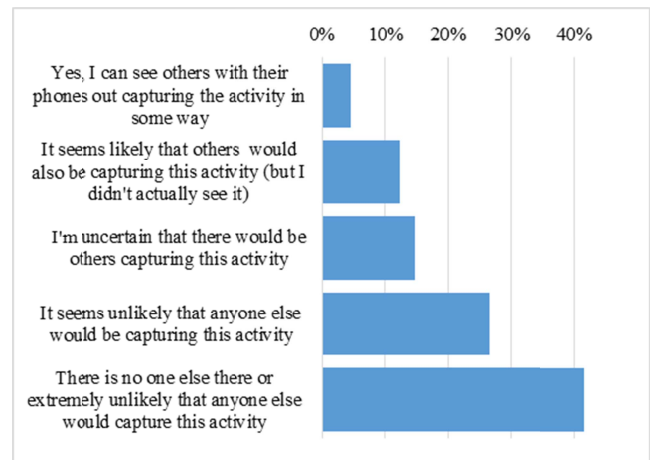
Figure 6: Crowdsourced responses to, "Are other people who are also capturing the activity using their phone in some way at the same time (taking photos, recording video, live streaming, etc.)?"

In the interviews, we asked whether they noticed events which had more than one live streamer broadcasting. Besides the initial story from P1 of watching the boxing event, we heard several other anecdotes where this was already occurring. P13 orchestrated multiple people to live stream at meetups with business clients to extend their reach with their audience. P16 played a game of hide and seek while each player was live streaming. MP6 even programmatically used location services to detect others starting a live stream near him and collect their Twitter handles to check out people who shared his interest in live streaming that event.

Even if they did not notice others live streaming at the same time, they could readily anticipate situations where it would be interesting, especially as live streaming becomes more pervasive. P15 noticed several live streams coming out of the Coachella music festival, albeit hampered by poor network connectivity, and projected that, "It would be cool to jump from my stream to another stream at the same event". P20 observed, "Everywhere you stand it's your point of view… and we're all so unique… Lots of people who could not be there and therefore, this is their way of actually being live and participating in an event…" Many of those interviewed could see potential opportunities for multiple live streams from an event.

DISCUSSION

Our data document a snapshot of practices during the important early adoption phase of this wave of mobile live streaming apps. We reiterate that this study was conducted very early in the life cycle of these apps, within months after they were launched. Recent usage data released by Periscope in August 2015 [19] shows that daily active users had increased about five-fold since the time we conducted our study. While the death of Meerkat has been predicted from losing users, they might be able to innovate in a still-emerging field [9]. It is sobering to note that almost all of the previous wave of live streaming apps that were studied [6, 15] are now defunct about five years later. One scenario for taking live streaming mainstream would be the involvement of a major player such as Facebook [4].

We see the features embodied in Periscope and Meerkat as potentially disrupting current social media practices. We wanted to study early reactions to these features to help shape how live streaming continues to emerge and evolve. Our study contributes an early understanding of practices around what live streams are being viewed, why broadcasters live stream, and how they interact with viewers. It also revealed the potential of communities around clusters of live streams from the same event, design implications for helping find streams, and important areas for future work.

Current Live Streaming Practices and Content

During the interviews, most of the streamers described that they were motivated to live stream to develop their personal brand. The diversity of content that comprises each individual's personal brand is reflected by the diverse live streamed activities, listed in Figure 2. Reflecting on these activities reveals a few different dimensions for categorizing them. Some of these activities are *expository*, where the streamers are directly explaining their opinions or showing their skills through chatting, demonstrating, or hosting "how-to", ask me anything, or talk show sessions. These activities give the streamer a chance to directly expound upon their personal perspectives that constitute their brand. Others are *experiential*, where the streamers want to share something they think is interesting, like an event, scenery, social gathering, or something funny. These activities illustrate their personal interests and tastes, which is another way of demonstrating their brand. Interviewees also shared that some live streams were work-related whereas others were for entertainment. Many interviewees liked that they were sharing across these dimensions of expository, experiential, work-related, and entertainment live streams as a way of building an authentic personal brand that gave viewers a comprehensive view of their personality. It is this unedited, and somewhat unpredictable, view into one's life that gives live streaming an authentic feel, and also helps streamers grow in their life skills of dealing with the unexpected.

Naaman et al. [17] identified a related dichotomy between Meforming (content that focuses on one's self) and Informing (social interaction around sharing information with others) in Twitter. Like Naaman, we found both: much of chatting, AMA and our expository streams are Meforming, most of the rest and our experiential streams are Informing. Like Naaman, we found more Meforming than Informing in live streams. Meforming live streams are largely chat sessions streams from indoors that leverage the social media notification, but use a mobile device to conveniently remediate a web cam on a computer. Clusters by definition exclude Meforming live streams (as multiple streams come from an event, not from me), and thus are an interesting filtering mechanism for Informing events.

In one sense, starting a live stream is very low effort, requiring only a few clicks on a mobile app to start a stream. In another sense, the interviews revealed the effort involved in attracting views and a following. At the lowest level, there is crafting a clever title and thinking in advance about potentially interesting sites along the way during the day that would make for a good live stream. More work is then invested to develop and curate a network of followers within the apps and on Twitter to propagate live stream notifications. Even more work is needed to build community by following those who follow you, watching others' live streams, and contributing to their streams. We also found evidence for social management of inappropriate material as another form of community work. As is typical for social media, it is easy to get introduced to the basic features of streaming and viewing live streams, but there is substantial latent community building work involved.

While our data provide plenty of evidence for the popularity of streaming, viewing, and interacting over live streams, it seems likely to be concentrated among popular streamers and frequent viewers, similar to patterns found in other user generated content sites. While we recruited interviews with people who showed a high volume of streaming activity, we did encounter one interviewee (P1) who was uncertain about continuing to stream. Despite trying many different kinds of live streams, the limited viewers and engagement that he had received left him uncertain about continuing to invest the effort. While our data focused on frequent live streamers, future research could explore those who tried live streaming but did not continue to help identify the reasons why people abandon live streaming and ways to keep them engaged.

Communities around Clusters of Multiple Streams

We were most intrigued to hear about the potential for clusters of multiple streams from the same event, even after only a couple months of launching these apps. While prior work [29, 31] had found clusters that represented events in more mature social media (Instagram, Flickr), it was notable to see them in the first months of live streaming app usage. We believe it would be interesting to aggregate across all geo-tagged and time stamped social media (live

streaming, Instagram, Twitter, Facebook, etc.) to collect multiple perspectives through various media of an event. We see several interesting attributes about these clusters.

First of all, having multiple live streamers broadcasting the same event is a valuable, social filtering function for events that might have broad public interest. Given the large number of live streams that can be available at any given time (and the substantial majority of them with little civic value), highlighting these clusters would help viewers find events happening now that are likely to be of public interest. It gives viewers a strong, social cue to find interesting streams beyond scanning the titles. While stream clusters focus attention on the subset of live streams that are captured in public settings, these are the ones that are more likely to have civic value [6]. These clusters also offer multiple perspectives on these events, letting viewers choose what aspect of the event to follow.

Furthermore, as a real time, interactive medium, identifying these clusters in live streaming apps gives viewers the opportunity to help shape the coverage of the event. This interactive feedback goes beyond recent research that has explored leveraging multiple video streams from live events. Schofield et al. [22] developed Bootlegger, which co-opted music fans using their mobile phones at a live concert into a camera crew to produce a high quality concert video. While the prototype helped the recorders feel more connected to the live event, there was no live interaction with the viewers, who watched the video after the event. Velt et al. [27] explored how remote viewers could experience music festivals remotely through viewing multiple live and edited video and audio feeds. While they could experience the event live, some preferred time shifted viewing to accommodate when they had the time available. Furthermore, they did not have direct ways to give live feedback to those streaming the feeds, and thus could not influence the coverage of the event.

In clusters of multiple live streams, we see an opportunity where viewers could actively give streamers feedback on their streams by encouraging them to continue or even directing them to locations of interest at the event (perhaps based on monitoring other social media coming from the event). While Periscope has since introduced a map view of live streams that would make it easier to discover these clusters, they have not enabled coordinating and communicating among the streamers and viewers of live streams that are in proximity to each other.

We see these clusters as *impromptu communities* that form around events of shared interest. These clusters turn individual, personal live streams and other social media posts into a higher-level event that affords collaboration among the streamers and viewers. These clusters could represent a new form of communication around a shared interest in real-time events that has the richness of video, pictures and other media, can extend to large-scale audiences, and brings together people that are not otherwise familiar with each other. We would like to understand what kinds of activities lend themselves to multiple live streams and identify ways of supporting these clusters. We would like to explore coordinating among the streamers and viewers of live streams within a cluster to create a more compelling way to share in these events.

Design Implications for Finding Streams

Several interviewees commented that they would like additional support to find streams that are of interest to them. Currently, live streams are discovered through explicit social following or browsing a list of streams that are currently live, which relies heavily on the title to attract viewers. Our interviews suggested that the list of currently available live streams is getting too large to effectively browse. Discovering live streams of interest is somewhat urgent because they can only be found during the short time they are available (in contrast to finding archived YouTube or Instagram videos). YouTube also offers search and social recommendation for finding videos. A design implication for live streaming apps is providing other mechanisms for finding live streams to view. Discovering clusters of live streams around an event is one way to highlight streams that are likely to be of public interest. The apps could also help viewers discover streams by location (such as Periscope's map UI), hashtag, or searching through titles.

Future Work

Our study also suggests future work beyond the research questions we explored. Our interviews focused on frequent streamers and we were able to ask about their viewing practices. We expect more can be learned from people who only *view* live streams. They represent the majority of live stream users who invest less effort by just viewing streams, and likely have different motivations and use practices than the people that we interviewed who both stream and view.

We have largely treated Meerkat and Periscope as equivalent live streaming apps, even though they have some important differences in their platform and user experience. Meerkat allows scheduling live streams in advance within the app, while Periscope allows replaying live streams within 24 hours. Meerkat allows one heart per stream, functioning as a "like" signal for the stream, whereas Periscope shows a heart for each screen press, providing a signal that is more localized to moments in time within a stream. Bursts of hearts are visualized as a stream of floating hearts in Periscope, leading to some gaming behavior around hearts. They have nuanced differences in controlling how live streams are announced and how they can be joined. While comments surfaced in our interviews of some implications of those differences, especially among the people who tried both, we did not systematically investigate them. Especially given the work involved in developing a social following within each app, most interviewees wanted to commit to one platform. Comparing and contrasting between Meerkat and Periscope usage

practices may give insight into design implications for developing future features for these apps.

It is important to keep in mind that this is a highly dynamic, early-adopter stage for live streaming. Even during the weeks of our study, Meerkat announced new integration with Facebook, opening up an API, and a beta version of an Android app, while dealing with Twitter cutting off their access to the Twitter social graph. Periscope's popularity was bolstered by its acquisition by Twitter. Both services have been getting scrutiny around piracy and copyright infringement for being the vehicle used to share highly publicized media events, such as a championship boxing match. Clearly, the evolution of the features within these apps and external factors regarding their role in the overall media ecology can have dramatic impacts on how they are used. While our data provide an important early snapshot of usage practices and opportunities for live streaming, more research will be needed on this emergent media.

Our study gives an early glimpse at a rapidly evolving social communication technology. Our observations give a snapshot of usage practices at this time, as well as opportunities for new shared experiences that could be enabled. We look forward to how these observations that document initial use practices could be compared to future practices as they continue to evolve as well as shape future live streaming opportunities.

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