Investigating the Role of Real-Time Chat Summaries in Supporting Live Streamers

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ABSTRACT

Live streaming platforms have become established communication channels where streamers and viewers can communicate through the chatbox. While there are numerous benefits to streamer-viewer interactions, managing messages can become challenging for streamers, especially during high-activity periods. In this paper, we investigate a strategy to supporting streamers that involves providing them with real-time summaries of chat messages. We investigate the feasibility of this approach through a prototype called the Stream Assistant, which provides automated poll summaries, a Word Cloud depiction of chat messages, and an overview of popular Emotes in the chat. We explore the potential utility of this approach in a multi-session study with 10 streamers, where we interviewed participants on their current chat management approaches and perceptions of the Stream Assistant after using it during one of their live streams. Our findings highlight the role of the chat in boosting engagement and audience growth and illustrate how streamers from different domains balance the chat with their activity. Our findings also indicate that many participants were enthusiastic about the Stream Assistant's lightweight polling, whereas the utility of the other features might depend on the pace of the chat and the intensity of the streamer's activities.

Index Terms: Live Streams—Chat Management—System Design—Qualitative Evaluation

1 INTRODUCTION

Live streams attract audiences worldwide through their unique mix of real-time video content and interactive chat opportunities. In recent years, platforms such as Twitch, Facebook Live, and YouTube Live have witnessed exponential growth, attracting millions of viewers who follow their favorite streamers' broadcasts [6]. Live streams are a powerful avenue for enthusiasts across diverse fields (e.g., gaming, art, music, and topical discussions) to share their passion and skills in addition to serving as a way to generate revenue [14].

While live streams provide a unique opportunity for real-time communication between streamers and viewers, the rapid and continuous flow of chat messages can be a significant challenge for streamers, particularly as their viewership increases [42,46]. Streamers can find it difficult to both focus on their streaming activity and keep up with the high speed of the chat interactions, which can lead to missed messages, difficulties in responding to viewers' questions promptly, and missed opportunities for meaningful interactions [56]. Prior work has investigated several ways to support chat interactions (e.g., [6, 15, 34, 43, 52]), however, the emphasis has typically been on techniques that involve either viewer-sourcing (e.g., [27, 33, 35, 39, 53]) or generating summaries of the chat intended for post-session consumption (e.g., [11, 17, 29]). Approaches to helping streamers monitor the chat in real-time without requiring extra audience effort are still largely under-explored.

In response to challenges faced by live streamers in managing chat interactions, in this paper, we explore an approach to supporting streamers that is based on providing glanceable, real-time summaries of chat messages. Informed by findings on the nature of chat interactions during live streams (e.g., [10, 41]), which we supplemented by observing 33 diverse live streams, we designed an exploratory prototype called the Stream Assistant. The Stream Assistant provides the streamer with three forms of real-time chat summaries. The first feature allows the streamer to poll the audience verbally and see a distribution of the most frequent responses. The second displays a word cloud of the most popular words in the chat, and the third feature displays the most frequently used emotes. In a two-session study with 10 experienced live streamers, we use this prototype to investigate streamers' chat management goals and their perceptions of whether these types of real-time summaries can help them maintain their desired level of chat awareness.

Findings from our study indicate that streamers leverage the chat to drive conversation, retain viewers, and foster a sense of community. When managing the chat, participants expressed that they try to acknowledge all messages to ensure that their community feels heard, however, it becomes difficult to do so as the chat speed increases or their streaming activity intensifies. After utilizing the Stream Assistant for one of their live streams, most participants viewed the Polling feature as a valuable extension based on its ability to support lightweight polling. Feedback on the Word Cloud and Emotes features was mixed. Participants with prior experience with larger streams could see benefit to having these types of real-time summaries, whereas others found that they could keep up with the chat content without the summaries.

The contributions of this work are twofold. We use findings from the literature and stream observations to propose real-time summaries that do not require extra viewer effort as an approach to assisting streamers with fast-paced chats. We also present findings from a multi-session study, where we explore streamers' chat management goals and their reactions to the Stream Assistant's chat summaries after using the prototype during a live-streaming session (for an average of 4.6 hours). Our findings provide an increased understanding of the role and importance of chat for streamers and how real-time summarization techniques might help or hinder chat awareness.

2 RELATED WORK

In this section, we explore previous research related to the social impact of live streams, audience engagement, advancements in interface design and technology, chat communication and management strategies, and content summarization.

2.1 Social Impact of Live Streams

Live streams have become an increasingly popular way for people to connect [30]. The impacts of live streams have expanded to and been investigated in a range of social activities and contexts, including cultural heritage [32], companionship [24, 47], matchmaking [19] and fitness [13]. Live streams can serve as a gathering point for

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people with common interests, which can facilitate the formation of relationships, from friendships to romantic partnerships [45]. Network social presence can influence viewers to support the streamer at three levels of social support, including economic, emotional, and instrumental [55]. At the same time, because a streamer has to interact with several viewers simultaneously, it difficult for them to establish an emotional social interaction with the viewers [55].

2.2 Live Stream Audience Engagement

Several studies have explored factors that influence the live stream experience and engagement from both the streamer [4, 5, 26], and viewer perspectives [49]. These studies have found that giving viewers influence options improves the live stream experience [26], using various forms of communication (e.g., use of images and videos in chat) boosts engagement [4], and support from the streaming community can affect how streamers create content [5]. Our interview findings provide further insight into how and why streamers seek to engage with their audience via chat.

Other research on audience engagement has focused on analyzing chat conversations. Some studies have examined emote sentiments by conducting sentiment analysis on chat messages [8], or have explored how streamers utilize and gather information about their performance and community [36]. More analytical work has explored specific characteristics of chat messages. This work has found that chat messages in high-viewer streams tend to be shorter, repetitive [10], and contain more emotes, compared to low-viewer streams [41]. Each live stream channel also tends to have its own unique language variety and emotes [41]. We use this literature to inform the design of the Stream Assistant prototype.

2.3 Novel Live Stream Interfaces and Technologies

Prior work has proposed numerous technological enhancements to live streaming platforms and interfaces with the goal of improving the experience for streamers and their viewers. Researchers have explored new interface approaches for live streams [6, 15, 34, 43, 52] and devised innovative methods for viewers to consume live streamed content [16, 18, 48]. Others have investigated ways of improving the streaming setup [9, 21, 28, 40] and accessibility [3, 22, 37]. The above work includes approaches like enabling viewers to send sketches and images as chat messages [34,52], allowing viewers to send real-time visual inputs to the stream's video feed [6, 15], and presenting those viewer inputs collectively to the streamer [6, 43]. Our work focuses on helping streamers stay aware of messages in chats that consist of text and emotes.

2.4 Live Stream Chat Communication and Management

In most live streams, communication between streamers and viewers is limited to a chatbox that continuously updates with new messages. These messages serve a range of purposes from expressing reactions, to providing commentary, to making direct requests to the streamer [42]. As the audience size increases, the chat often becomes chaotic, and managing and engaging in meaningful conversations within the chat can be challenging for the streamer [42, 46, 56]. Prior work has investigated a range of potential solutions. For instance, Danmaku [51] allows comments to appear directly on the streamer's video feed, reducing the glancing time for the streamer, while Conversational Chat Circles [39] aims to reduce chat overload by displaying only a subset of comments as voted on by the viewers. We investigate an approach that also aims to reduce streamer load by summarizing the popular words and emotes, but without viewer input.

Other research in live stream chat communication has investigated the role of moderators in fostering engagement and managing interactions within the chat community. This work has found that moderators, who are typically long-standing viewers, play a vital role in responding to issues that arise in the chat [44]. As live-streaming communities continue to grow, community management and moderation become essential for maintaining a positive and inclusive environment. Studies have examined the roles and responsibilities of volunteer moderators [44], moderation styles [50], moderator decision making [31], collaboration amongst a team of moderators [1], and conflict management strategies [2]. We view our approach as complementing rather than replacing moderators.

2.5 Summarizing Live Stream Content

Live streams take place in fast-paced environments, incorporating real-time video and chat interactions, posing challenges for both streamers and viewers to keep up with messages and events [27, 39, 53]. One approach has been to summarize the live stream content. For example, various projects have employed chat messages [12, 17], audio transcripts [11], and sports stream metadata [38] to summarize video [12, 17, 38] or audio [29] feeds or to highlight crucial parts of the stream [11, 12, 17].

Our approach is inspired by chat summarization work that has focused on detecting and analyzing the general sentiment and mood of the audience throughout the stream. For instance, Kobs et al. [23] highlighted the importance of emotes as indicators of audience emotions, showing how they correlate to stream events. Reis [42] developed a model to analyze collected chat messages and emotes in Twitch chat, calculating an aggregate sentiment for any given time during the stream. Similarly, our Stream Assistant prototype presents a summary of popular chat content for any given time of the stream, showcasing the most frequent words and emotes, but does so without performing sentiment analysis or emotion labeling. Storychat [54] provides a narrative-based viewer participation tool that shows the chatroom sentiment as an animated avatar. Similar to Storychat, we investigate providing a real-time representation of activity, however, our prototype presents it to the streamer in the form of a real-time polling chart and the words and emotes that are used in the chat. Given the real-time updates, the Stream Assistant also offers streamers the flexibility to adjust the time frame for the summary reports to allow the streamer to tailor the reports to particular areas of interest.

Other work has focused on generating real-time summaries using viewer-sourcing methods by offering viewers poll options on game decisions [27], or employing viewers' written summaries [33] or votes to identify and highlight important moments [33, 53] and messages [39] in the stream. We study an approach that does not require any extra viewer effort.

3 Stream Assistant

In this section, we describe our approach to supporting streamers in managing the chat in live streams. We first discuss chat-management practices and chat characteristics that we observed in a selection of live streams. We then describe our prototype's general design goals and its three main features.

3.1 Observing Chat Management Practices and Characteristics

To better understand the nature of chat interactions in high-speed chats, two of the paper authors observed 33 Twitch live streams in the gaming, arts, and music categories, with active viewers ranging from hundreds to thousands. While observing the streams, we noted the methods employed by streamers to communicate with their audiences, including in situations where the chat's speed became rapid. We also looked for properties of the chat during periods of intense messages. Finally, we noted any Twitch extensions the streamer used to facilitate the streaming experience for either themselves or the viewers.

In observing the streams, we noticed that streamers frequently asked questions and scanned the chat quickly for responses. While some streamers used polling tools to ask questions, the more common practice was to ask the questions verbally and scan the chat

manually to get a sense of audience responses. We observed that the chats often became chaotic when viewers were discussing an interesting topic or reacting to an exciting event, resulting in a surge of short messages and emotes. This occurred most frequently in gaming streams with large viewer counts (e.g., 1000 - 3000 viewers). The most common chat-management practice was to read messages aloud and either answer or acknowledge them; however, streamers would often stop doing so as the speed of the chat accelerated.

The extensions we observed being utilized by streamers, either by viewing their stream or via their "About" page, primarily focused on channel customization, emote creation, stream scheduling, and tracking various statistics (e.g., viewer retention, follower growth, and average view count). Other than the occasional use of polling extensions that we described above, we did not observe streamers utilizing any extensions specifically designed to help them keep up with fast-paced chat conversations or with reading the chat messages.

3.2 Design Goals

Our design goals for the prototype focused on helping streamers manage high-speed chat messages and facilitate communication with their viewers during a stream. We wanted to investigate a solution that assists the streamer in extracting key information from the chat to help them process the chat messages within the limited time they have available to read and respond. To this end, we created a prototype system that captures chat messages and generates summary reports (see Fig. 1) for the streamer, with a focus on minimizing any extra effort required from the streamer. In providing these summary reports, the objective is to provide streamers with an overview of their audience's responses and reactions without requiring them to read each message individually. We also wanted the summary reports to support streamers' common practices of asking questions verbally as opposed to using formal polls.

3.3 Prototype Description

As described above, we observed that many streamers prefer verbal questions to setting up polls manually and that chats can become flooded with short messages and emotes. Our prototype, which we call the Stream Assistant, has an interface similar to the Twitch interface in that it displays the live video feed and the chat box next to each other. The Stream Assistant, depicted in Figure 1, includes an additional panel that displays three features that process the chat messages to generate summary reports: a Polling feature, a Word Cloud feature, and an Emotes feature. As soon as the streamer starts using the Stream Assistant, the chat messages will be stored in the database and the features will refresh the displayed data every 5 seconds. The Stream Assistant also includes two sliders to allow the streamer to interact with these features: one to set the time frame for reports and one to control how frequently the reports update. The default setting for the time frame is the past two hours of the stream, whereas the default update frequency is every 5 seconds. We describe each of Stream Assistant's three features in more detail below.

Polling Feature

Streamers poll their audiences for various reasons, one of which is to inform the direction of their stream [25]. At the same time, setting up and managing polls can be challenging, which can impede a streamer's ability to make timely decisions [27]. The purpose of the Polling feature is to facilitate the practice that we observed of streamers choosing to ask verbal questions rather than to set up a formal pool.

As shown in Figure 1(A), with the Polling feature, streamers can ask a question verbally without typing or setting up a poll and gradually see a distribution of the responses in the chat. When a streamer poses a question, viewers typically populate the chat with answers to that question. By default, the prototype will display statistics for the top four responses. Streamers can also add their own keywords to monitor. Currently, as a proof-of-concept, the prototype summarizes the frequency of the most popular individual words or keywords supplied by the streamer. It is also currently left up to the streamer to customize the polling response period by adjusting sliders (see Fig. 1(D)). We use this implementation as a starting point to investigate streamers' reactions to the idea, leaving the incorporation of more sophisticated polling detection and response summarization algorithms for future work.

Word Cloud Feature

In order to provide the streamer with a real-time summary of the chat that is more comprehensive and less quantitative, the system creates a word cloud by extracting words from chat messages. It excludes stop words, usernames, bot messages, and repetitive words within a single chat message. The top 15-20 words used in the chat within a specified time frame (see Fig. 1(D), left slider) are then displayed in a word cloud format, with the more commonly used words appearing larger than the less frequently used ones. The exact number of words shown in the Word Cloud depends on the length of the words and the space available.

There is some overlap between the Word Cloud and Polling features in that the top four words in the Word Cloud are also the default terms used by the Polling feature. Even in the event that the streamer does not customize the keywords in the Polling feature, the two features serve different purposes. By displaying statistics for a selection of terms, the Polling feature aims to facilitate decision-making where the quantity of different chat responses is important. The Word Could feature, on the other hand, provides more of an overview of words in the chat.

Emotes Feature

One distinguishing aspect of most live stream chat communications compared to other video-conferencing platforms is the use of emotes, which are graphical representations that convey emotions, reactions, or specific meanings within the chat [42]. Previous research has shown that high-speed chats and large streams tend to contain more emotes and more emote repetitions [41]. Twitch emotes, in particular, can convey complex emotions better than emojis and express feelings faster than words [42]. The Emotes feature (see Fig. 1(C)), aims to provide the streamer with an overview of the chat's atmosphere by displaying the top 10 frequently used emotes in the chat. Similar to the Word Cloud, the system extracts emotes from messages and presents the most popular ones in the selected time frame, with the more popular emotes displayed in larger sizes.

3.4 Prototype Implementation

We used HTML, CSS, and Javascript to develop the frontend of the Stream Assistant and Express, Node.js, and SQL for the backend. The prototype utilizes the Twitch API and two "npm" packages, "tmi-emote-parse" and "twitch-emote-parser" to extract messages, emote images, usernames, and message timestamps. The extracted data is stored in a SQL database on the backend. The frontend receives new data from the backend using server-sent events. The sliders are set by default to update every 5 seconds and display data from the last two hours. Any changes to these settings are communicated to the backend via HTTP requests, allowing the backend to adjust the data according to the streamer's preferences. The polling feature and word cloud are implemented using JavaScript packages, while the emotes feature uses only HTML and CSS.

4 Study Method

We conducted a primarily qualitative study with 10 experienced streamers to learn about how streamers manage their chat and to elicit their reactions to the Stream Assistant prototype. More specifically, we aimed to investigate the role of the chat in participants'

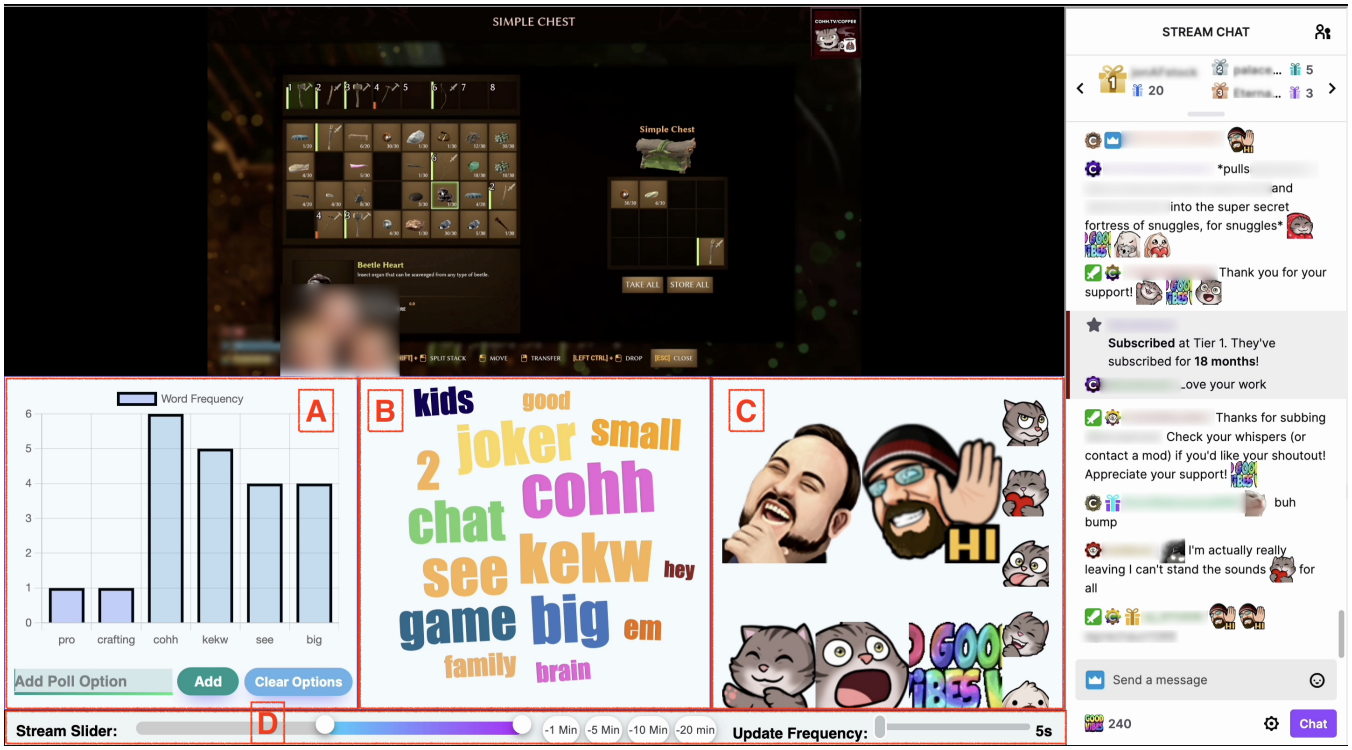

Figure 1: The Stream Assistant prototype: (A) The Polling feature provides statistics on the most frequently used words in the chat. By default, the feature displays a distribution of the top four most frequent words, or alternatively, the streamer can customize the set of keywords displayed in the graph. The streamer can also view the count of each keyword by hovering the corresponding bar in the graph. (B) The Word Cloud feature displays the most commonly used word in the chat, with the size of each word reflecting its relative frequency. (C) The Emotes feature displays the top ten most used emotes in a chat, with the size of each emote indicating its rank. (D) The streamer can control the time frame of the reports by adjusting the duration manually using the slider or preset buttons. The streamer can also set the update frequency of the features from 5 seconds to 30 seconds.

streams and their current chat-management strategies. We also used the Stream Assistant prototype described above to probe into their views on the potential advantages and disadvantages of having access to real-time summaries of chat activity throughout their streams.

4.1 Participants

We recruited 10 Twitch live streamers (5 Men, 5 Women) by advertising on social media and in Twitch communities, and by reaching out directly to streamers (e.g., via email and Discord). We had originally hoped to recruit streamers with a minimum of 100 viewers per stream, however, due to recruiting challenges, we also accepted streamers with fewer than 100 viewers but whose chats seemed to be quite active. In the end, our participants had 25-130 viewers in their streams. Our participants streamed in the gaming and creative domains, including sculpting, drawing, and Lego building. Further details on the participants and their stream sessions can be found in Table 1. Participants received $75 CAD for their participation. The study was approved by our institutional research ethics board.

4.2 Study Procedure

The study consisted of two sessions, which collectively included two semi-structured interviews and a live stream using the Stream Assistant. The first session consisted of a semi-structured interview to explore the participant's streaming experience, communication strategies with their audience, and their use of chat-management tools. Following the interview, we introduced the Stream Assistant prototype, explained its features, and gave participants the opportunity to ask questions. This first session lasted 30 to 40 minutes.

During the second study session, we asked participants to use the Stream Assistant during their live stream. Prior to the stream, we asked participants to share their browser screen showing the tool on a Zoom call, allowing us to observe their activities and use of the tool. Two of the 10 participants declined to share their screens. All participants used two monitors during their streams, typically keeping the Stream Assistant open on their second monitor. After the stream, we conducted a semi-structured interview with each participant to collect their feedback on the Stream Assistant and its impact on their streaming experience. The live streams ranged from 1.5 to 7 hours (mean: 4.65 hrs, stdev: 1.66 hrs) and this second semi-structured interview lasted 20 to 30 minutes.

4.3 Data Collection and Analysis

Our primary source of data was the interviews, which we transcribed in full and analyzed via open coding. The first author began by identifying relevant quotes and assigning initial codes. Two researchers subsequently revised the codes and their connotations through several iterations, ultimately categorizing codes with similar definitions into themes [7]. We also extracted some quantitative data from the structured parts of the interview, where we asked participants to rank the features and indicate if they would like to use any of them as extensions in the future.

Our secondary sources of data were the observation notes and screen recordings from the stream sessions. We used the observation notes to analyze the usage of the Stream Assistant. We used the screen recordings to estimate the speed of the chat, the approximate number of messages sent, and the number of viewers.

Table 1: Participant and Stream Session information

Participant ID	Gender	Domain	Stream Hours	Viewers	Messages (approx)	Estimated Chat Speed (msg/min)	Experience
P1	M	Creative (Sculpting)	5	90-110	600	2	10 years
P2	W	Gaming	4	85-120	480	2	2 years
P3	W	Art (Drawing)	4	65-100	720	3	7 years
P4	M	Gaming + Art (did gaming)	3	25-70	360	2	3 years
P5	M	Gaming	6	65-100	720	2	5 years
P6	M	Creative (Lego building)	6	100-130	1080	3	7 years
P7	M	Gaming	6	55-90	720	2	2 years
P8	W	Gaming + Art (did art)	4	25-50	240	1	2 years
P9	W	Gaming	1.5	45-80	180	2	3 years
P10	W	Gaming	7	65-90	1260	3	6 years

5 FINDINGS

We first discuss findings from our initial semi-structured interview, where we asked participants about their perceptions of the importance of the chatbox and how they manage the messages they receive. Next, we discuss their stream sessions, how they used the Steam Assistant during their streams, and their impressions of the tool's advantages and disadvantages.

5.1 Perceived Importance of the Chat in the Stream

In this section, we discuss the participants' views on the significance of chat in their streams and its influence on their streaming experience and audience growth.

5.1.1 Engagement, Building Audience, and the Community

Participants discussed using the chat feature on Twitch to drive conversation, increase engagement, and retain viewers. Almost all participants described how they value Twitch's chat due to its live interaction capabilities. For instance, they ask their audience about their daily lives to drive conversation or interact with new viewers to encourage return visits.

> *"When it comes to reading chat, I'm just trying to drive conversation and engagement for sure. So you know, checking in with my community, seeing how they're doing what's going on in their day-to-day lives." - P6*

Several participants indicated that the chat is more than just a tool to engage individual viewers; it also helps create a sense of community. For example, the quote below describes how the chat provides a sense of connection and friendship that sometimes even extends beyond the online world.

> *"And it's just cool to really have known some people online. Just did the stream for 10 years, so that's a long time. Actually, I met my wife through a stream too, she was just a chatter when we first met." - P1*

Two participants described how they dedicate significant portions of their streams to engaging in conversations with their viewers and establishing connections. The following quote illustrates this type of effort:

> *"You will get some sort of following to come in for your first stream, and hopefully continues into the future and build [the audience] from there [...] A community and building a community, it's number one. I always made a point to interact as much as possible with my viewers, especially with the regulars. I try to remember some sort of information about the regulars, like where they live, something they're into, you know, or I might have a certain way of seeing their name." -P7*

This sense of community can have practical impacts on the quality of the stream. For example, the quote below describes how the streamer's viewer community influences their streaming activities:

> *"I leverage my viewers for having a lot of say and kind of what happens within my streams. So one of my normal weekly streams is something I call Viewer Build requests, where they will suggest ideas in chat, I'll put them in a poll, then they vote on it, and then I build whatever is voted on." -P6*

5.1.2 Dedication to Reading Every Message

Almost all participants showed a strong commitment to tending to all the messages in their chat. They emphasized that they prioritize the chat and want to respond to every message. As the following quote illustrates, this dedication to responding can become a source of stress:

> *"There is definitely a small element of stress, I mean, because I don't want to miss messages, and it's definitely, especially for smaller streamers. There's almost a fear of missing a message or trying to make sure that you respond to every single person because otherwise, you know, they might get upset and not come to the stream or something like that." -P5*

One participant, who conducts both gaming and drawing streams, indicated that they used to attend to all messages but stopped doing so after realizing that it was taking too much time away from their activity.

> *"I've always been very connected with my chat, especially early on, when I was a smaller streamer, where I would be very active with my chat, I would read and respond to pretty much every message.[...] So I stopped doing that eventually, and I tend to just focus on messages that directly reference me, like when they add my username or when they say my name is, I read those, but for the most part, I tend just to let them scroll now."-P4*

5.2 Chat Management

Prioritizing Certain Messages

When we asked participants about their approaches to reading and managing messages in the chat, their responses varied, however, one common strategy was to prioritize certain chat messages. Several participants mentioned different criteria they use to determine which messages to prioritize, including the most recent messages, messages that mention their usernames, or messages from known viewers.

> *"I just kind of go talk to the bottom 3 messages one by one, unless somebody is like telling a story, in which case I'll wait for the next bit. I will read that bit out as a whole section, and then I'll go back and this like chunk in the comments I missed, and I'm pretty good at managing." - P9*

Other participants mentioned more personalized approaches that they felt worked well with the nature of their streaming activity. For example in the quote below, P1, a sculptor, describes how they use their peripheral vision to monitor the chat. Another participant described taking explicit activity breaks to interact with the audience via the chat.

> *"It has become second nature like I'll be just working, and with my peripheral vision, I'll see the chat move, and I'll automatically look. And the way our artwork is, you don't need to be constantly moving and working the whole 5 hours. So chat's over here, all the way to the right, and I'm just working, and it's really the movement of the chat that gets my attention." -P1*

Chat Volume Impacts Chat Management

While participants had different techniques for reading messages, most indicated that chat volume affects their chat management. Some participants said they have an easy time handling messages when there is a low number of viewers or a slow chat, but as the number of viewers and/or the chat speed increases, they find it difficult to implement their usual strategies.

> *"For the most part, just because of the size of my stream, I do find that generally keeping up with my chat is pretty manageable [...] So it's been a little bit easier to manage, just because I don't have the volume of people that would make it difficult. But I have done a couple of big streams for certain events in the past, and that is definitely when it is much more difficult to keep up. I think the most viewers I had on my stream have been like 17,000 for a large event, and that was certainly one where you kind of just realize you have to pick and choose what you reply to." -P6*

Finally, Twitch has a "Slow Mode" feature, which is designed to help streamers manage fast chats. "Slow Mode" works by limiting viewers from sending messages for a specific duration of time as determined by the streamer. Several participants revealed that they had used this feature when they had a high number of viewers.

> *"Yes, I have used that primarily when I've done bigger events. Anytime I had a substantial increase in my viewership, due to, you know, being on the front page of Twitch, or participating in the event that drives a lot of viewers." -P6*

The fact that participants had experimented with this feature when they had a high number of viewers suggests an interest in investigating solutions for high-speed chats. One streamer who used the slow mode in the past, however, said that they had stopped using it because it places limitations on the viewers, which many viewers do not appreciate.

> *"There was a time where I would leave it on to like the lowest setting [...] But eventually, I learned that people just like to type, and you don't like having slow mode on, so I just turned it off."-P4*

Stream Activity Influences Chat Management

Our findings indicate that participants' chat management is also affected by their streaming activity or agenda for the day. P6, who builds LEGOs in their streams, finds it easy to multitask and interact with their chat audience because the nature of their activity allows for flexibility.

> *"Luckily, LEGO building is, for the most part, pretty easy to multitask with, so I can be doing some building and looking at chat at the same time. It's maybe not as intensive as something like a video game where you have to be really focused on what's happening on the screen at any given time." -P6*

P8, who did a drawing stream for the study, noted that chat activity changes for them based on their stream schedule. They dedicate time to conversations with the viewers at the beginning when they are not actively drawing, and as they become more involved with their activity, there is less to discuss and more to learn for the viewers. Therefore, they find chat management easy because viewers naturally shift their focus to the streaming activity and send fewer messages.

> *"[The viewers] will come in and chat a little bit at the beginning, and then because I'm playing music and kind of talking to myself, they'll kind of leave me on in the background (of what they do) because all I'm doing is less interactive. So I do find that usually on art streams, I'll have a very active chat for maybe the first couple of hours because I typically stream for about 4 hours, and then around hour 3, it tends to get a little bit quieter, just because, you know, I'm doing the same thing, and it's more of a background effort." -P8*

On the other hand, chat management becomes challenging for streamers who engage in demanding activities such as gaming. Viewers continuously comment on game events and engage in conversation during the activity, which creates challenges for streamers trying to balance their focus on the game with the ongoing chat discussions. P5 mentioned that when playing games on their stream, they would rarely stop the game to read the chat and just glance to catch a message every once in a while. P8, who does both gaming and art streams, also compared their art streams, which are less demanding, with video games that generally need constant focus throughout the stream.

> *"With video games, it's often a little bit more interactive, obviously, because there's more to kind of engagement [...] I think [in art streams] when I don't have too many new things going on at once, It's quite an easy way to interact with them, Really" -P8*

In summary, we found that our participants employ personalized approaches to manage chat messages, taking into account factors such as chat volume and stream activity. Some participants reported that they are able to easily handle their chats due to the nature of their stream activity and chat volume, whereas others noted that implementing their preferred strategies can become difficult and stressful as the pace of the chat and demands of their activity increase.

5.3 Stream Assistant Usage

All participants utilized the Stream Assistant throughout the entirety of their streams, with the exception of one participant (P9), who stopped using the tool after 90 minutes. The 10 participants in the study streamed for an average duration of 4.6 hours, encountering an estimated average of 630 chat messages per stream, translating to an average of 2.2 messages per minute. To estimate chat activity, we used the screen recordings to count messages in 5-10 intervals of 20 minutes each, depending on stream lengths. Details on the individual streams are summarized in table 1.

The participants engaged with the Stream Assistant on their second monitor to varying extents. Six participants opted for the default settings, which featured sliders set for reports within the past 2 hours, an update speed of 5 seconds, and the Polling feature displaying the top 4 frequent words. When asked about their decision not to adjust the sliders, participants cited reasons such as wanting to experience the tool before making changes or simply forgetting to do so. Conversely, three out of the remaining four participants customized the sliders, and all four added custom words to track in the Polling feature. Some streamers used the Polling feature to both actively interact with viewers through polls and to monitor the popularity of specific topic words.

5.4 Stream Assistant's Perceived Advantages and Disadvantages

In this section, we use data from the second interview and observations from the stream sessions to discuss the Stream Assistant's potential benefits and weaknesses.

The Polling Feature was Fast and Effortless

When we asked participants which of the features, if any, they would like to use as an extension, 7 out of 10 participants cited the Stream Assistant's Polling tool as their preferred feature for an extension. Additionally, when ranking the features based on usage during the study, 6 out of the 10 participants ranked the Polling feature as the most used feature. Participants praised the Polling feature for its ease of use. They appreciated the convenience of quickly setting up and conducting polls as the following quote illustrates.

> *"I think that part is kind of fun when you ask where you don't have to set up a poll, and then you can see what people are voting for straight away. That's perfect. I don't have to touch anything, you know, because again, on Twitch, you have to do like /poll, and then add all the options you just see."-P3*

In addition to the ease of initiating the poll, one participant who did an art stream commented that the automatic polling aspect could

be particularly useful when keyboard access is limited by the streaming activity.

> *"The automatic Polling system, I think, could be really useful, especially if you've got kind of like a call-up situation going on where you might not necessarily be able to get to your keyboard, or something like that." -P8*

Limited Utility of Word Cloud and Emotes Features with Low-Volume Chats

While many participants were enthusiastic about the Polling Feature, participants had more mixed reactions to the Word Cloud and Emotes features. Some participants mentioned that these summaries were not necessary since they could easily read and keep up with every message due to their chat speed and stream agenda. For example, in the quote below, P5 mentions that they experimented with the features, but did not find that the features added value to their streaming experience since they were able to fully monitor the chat given the size of their viewership.

> *"I could keep up with the chat, and I would just also look at [the Stream Assistant] just for fun to see what it has tracked ... but for me personally, yeah, I don't think for like small stream is that would give much of a help in any kind of way because I can just keep up with the chat. Anyway, I can read almost everything."-P5*

Other participants indicated that they did not have time to use the features due to the nature of their activity.

> *"It all depends on what I'm doing in a day, you know, like today it was just us just me kind of painting this to the finish line. So there wasn't a whole lot of opportunity for viewer engagement."*

Some participants indicated that while they did not make extensive use of the Word Cloud or Emotes features during this particular streaming session, there were occasions where the summaries influenced their state of mind during the stream and allowed them to grasp the overall sentiment and tone of the chat quickly. One noted use case was during the chatting-only portion of a stream, where the conversation can become fast-paced and hard to keep up with. For P2, who mentioned *"it felt like I was more on top of things [...] it just put me in a better frame of mind"*, the Emotes feature provided her insights into viewer preferences and reactions. P4 also noted that the Word Cloud and Emotes features helped them catch up with the chat conversation after taking breaks.

> *"I took a small break doing something else, and I was gone for a while and, instead of like reading all the individual messages, I took the big words, and I did skim through what they were talking about, and it did help kinda like figure out what was going on in chat without me having to moderate the entire log, so just helpful in general." -P4.*

Furthermore, a couple of participants expressed interest in accessing the Word Cloud and Emotes output after the stream. They wanted to be able to review the nature and sentiment of the chat as a way to assess how the session went.

> *"Well, it's. Actually, I was really surprised at how effective like and helpful the Word Cloud was. That was. That's really smart [...] The only thing I would appreciate is like a way to output afterward, so I can look at it and be like, oh, sweet, I did that great!" -P10*

One participant thought they could potentially use the output of the Word Cloud to determine keywords to use to filter or moderate the chat in future sessions and use the output for the emotes for inspiration for future emotes that they want to design.

Utility Likely to Depend on Chat Volume

As discussed in the previous section, some participants found that they could easily keep up with their chats in this particular stream session, limiting the utility of the Word Cloud and Emotes features. Participants with experience with larger streamers saw a lot more potential for the tool to support them in those situations. Of the ten streamers interviewed, five mentioned that the Stream Assistant would be helpful for managing big streams with constantly moving chat messages. These streamers were speaking from their experiences of previously streaming with thousands of viewers. In these situations, participants felt that the Stream Assistant could provide quick insights into what the audience is interested in or discussing without the need to read the messages.

> *"You know the channel of my size, it can be very different. There can be some days where there's like nothing for 20 min in the chat, and there can be days where there's just non-stop chat scrolling, and I can't even keep up with the messages. [...]. I can see how in a big chat with like 1,000 chatters [the Stream Assistant] could make it easier to perhaps get a feel for what the chat is discussing." -P5*

> *"I have done a couple of big streams for certain events in the past, and that is definitely when it is much more difficult to keep up. I think the most viewers I had on my stream have been like 17,000 for a large event, and that was certainly one where you kind of just realize you have to pick and choose what you reply to.[...]. I do think I could see [the Stream Assistant] being a very valuable feature for people who have a lot of people in their community, and they can quickly get a sense of what kind of keywords are being discussed within their community so that it makes it easier for them to kind of continue to drive conversation and engagement" - P6*

Similarly, the tool's utility might also depend on chat speed. For example, P8, who had high-speed chat experiences, felt that the tool would be more beneficial in times of high chat activity.

> *"I can think of other streams as I've watched, and other streams I've been in, where I think something like that could be really useful, where you have a lot more chat, direction, and chat involvement and things like that." -P8*

Frequent Tool Updates were Moderately Distracting

When explicitly asked, 6 of the 10 participants mentioned that they found the tool at least somewhat distracting. These participants found that the movement of bars and the updates of the Word Cloud and Emotes distracted them from their main activity at times, with some participants citing this distraction as a primary reason for not making more extensive use of the tool during their stream. For P9, who stopped using the tool after 90 minutes, distraction was a primary reason.

> *"The information that was provided was more of a distraction, and I wasn't able to utilize it in any way." -P9*

Two participants, a sculptor, and a gamer, said that they rely on their peripheral vision to get notified of new messages and that the movement of the Polling bars impacted their ability to do so. The updates of Emotes or the Word Cloud features were not seen to be as distracting since these features were not moving vertically.

> *"Yes, just the word for the Polling with the Polling window kept distracting. The animated emotes weren't, and the words the way the words kind of work, because it's just the same motion as the chat." -P1*

Some of the participants who found the tool distracting said the level of distraction decreased throughout the stream as they got used to the tool.

> *"A little bit [distracting], Yes, initially, but I very quickly got used to it. It's just because, as you can imagine, it's a routine of like having certain things." -P5*

A few other participants expressed regret over not having adjusted the sliders as they felt that less frequent updates could have lessened the distractions.

6 Discussion

Our study provides insight into the role that chat plays in our participants' live streams, the strategies they employ to manage the chat, and whether real-time summaries have the potential to support their chat management objectives. The interviews revealed that chat messages are of the highest importance to our participants, particularly in contributing to increased engagement and fostering a sense of community among the viewers. Our participants adopted different approaches to managing messages, including prioritizing specific ones and adjusting their reading approach according to chat volume and stream characteristics. Our findings also point to potential advantages and disadvantages of the Stream Assistant's approach to real-time chat summaries. After using the tool during one of their live stream sessions, the Polling feature emerged as the most popular feature due to its speed and ease of use. On the other hand, the Emotes and Word Cloud features were not as widely embraced. Some participants liked the lightweight overview of the chat messages. Others expressed that the repetitive feature updates were distracting. This distraction, combined with the fact that many participants felt that they could keep up with individual messages given their chat's pace, meant that for some participants, these features carried more disadvantages than advantages.

Those participants who were most enthusiastic about the Stream Assistant's approach tended to have prior experience with high-speed chats. During our initial stream observations, we consistently observed a pattern in gaming streams where the chat experienced a surge of emotes and short slang messages during exciting in-game events. Similarly, our observations of just-chatting sessions in these streams, combined with our study interviews, revealed that controversial or interesting topics can trigger a continuous stream of short messages and emotes from viewers. Participants who had prior experience managing fast-paced chats saw potential for the tool to help them stay informed when reading individual messages was no longer feasible. We also hypothesize that the utility of real-time chat summaries may depend on the streaming activity. Streamers who engaged in creative activities, such as sculpting, drawing, and Lego building, were able to pause their activity to read chat messages and interact with their viewers. On the other hand, gaming streamers were often fully engaged in their activity.

There are a number of potential design improvements that could be explored in future work. Given participants' enthusiasm for the Polling feature, it would be worth investigating more technically sophisticated approaches to populating the response graph. For example, it might be possible to extract options from the question being posed, or to use topic summarization techniques to handle multi-word responses. It might also be possible to detect when a question is being posed to drop pins on the stream timeline to help the streamer adjust the report time frames. Researchers have also proposed and evaluated several improvements to the default Word Cloud library that we used in this initial prototype, such as columned layouts where words are grouped semantically [20]. Finally, it will be important to explore ways to reduce the distractions that the tool introduces. It is possible that with more time to get used to the tool, streamers might be more proactive in adjusting the report frequencies to better suit their needs. Alternatively, the tool could update the reports only on demand (e.g., via a button click) or use gaze-tracking to update the reports when the streamer fixates on those areas of the display. Future research could also explore whether streamers prefer to have access to the summary reports during the stream, after the stream, or both.

In addition to the potential design improvements described above, there are a number of limitations to our study findings that warrant further research. First, while participants used the tool for a reasonably long period of time (an average of 4.6 hours), it was during a single stream session where they also had to focus on executing their streaming activity for their viewers. Participants might have developed greater comfort with the tool with additional practice, for example, during a mock stream or over repeated streams. We had originally hoped to recruit streamers with large viewer counts. While we recruited only participants with active chats, we did not observe any of the high-speed chats that the Word Cloud and Emotes features were originally designed to support. Future work should, therefore, investigate ways to better connect with popular streamers to ensure that their perspectives can be represented in study findings. Similarly, future work should investigate the generalizability of our findings to a larger sample size. Finally, our study focused on qualitative data, which is highly interpretative. As the designers of the Stream Assistant prototype, we might have been biased towards seeing the positives in the data. Our strategy to counteract this bias was to explicitly look for (and report) counterexamples. Future comparative studies should investigate quantitative impacts of the tool on streamers' chat management practices, chat characteristics, streamers' workload and viewer engagement metrics.

7 Conclusion

In this paper, we presented the design and evaluation of a tool that aims to assist live streamers in managing their chats by providing them with real-time awareness of chat activity. Findings from a study with 10 live streamers showed potential for some of the tool's features, while highlighting the need to further investigate the tool's utility with streamers who have very large audiences. Given our participants' dedication to interacting with their audiences and the stress that this induces as their audience grows, future research should continue to explore ways to help streamers connect with their audiences at scale.

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