Entangled with Numbers: Quantified Self and Others in a Team-Based Online Game

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Quantification is a process that produces and communicates numbers, imbued with the expectation of generating knowledge and optimizing human behavior and social process. In this paper, we explore how quantification mediates virtual teamwork through an ethnographic study of quantification in League of Legends, a popular team-based online game with a highly competitive culture. In the game, rich statistics about each individual player's gaming history and performance are publicly available, analyzed and displayed on numerous third-party sites. We describe how players were entangled with numbers. They derived knowledge from numbers but struggled with proper ways of interpretation. They utilized numbers to quantify teammates and opponents, but in-game tensions and conflicts easily ensued. They noticed how quantification became burdensome and stressed the importance of proper use. We discuss how this case of quantified self and others manifests complex relationships between self-knowledge, numerical authority, and virtual teamwork.

CCS Concepts: • **Human-centered computing → Human computer interaction**; Empirical studies in HCI

KEYWORDS

Quantification, quantified self, quantified others, self-knowledge, numerical authority, interpretive flexibility, communicative trust, virtual team, League of Legends, multiplayer online battle arena, MOBA

1 INTRODUCTION

Different from collocated collaboration, in virtual teams, geographically distributed team members often face social challenges developing mutual trust and shared understanding [60]. Computer-supported cooperative work (CSCW) research has explored ways of conceptualizing and designing to support critical social elements in virtual collaboration, such as awareness [20] and social translucence [24]. As a way of enhancing social awareness, considerable work has discussed how means of representation such as a virtual profile might facilitate virtual collaboration [20,32,68]. Joining this stream of research, this paper analyzes how numerical representations of people, produced via quantification, impact virtual teamwork. Quantification in this paper refers to the general social phenomenon of producing and communicating numbers [26].

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Quantification has become a prevalent practice, as increasingly more computing systems are made available to generate and analyze numbers about many aspects of a person's work and life. Famously, the Quantified Self movement denotes a trend to use technology to acquire data about manifold aspects of people's daily life. The movement, manifested in the self-tracking of health-related aspects such as eating [13] and footsteps [31], has received lots of attention from HCI and CSCW researchers. Other studies have examined academic scholars' self-quantification through numbers of publications and citations [33,34,36]. However, quantification has been examined primarily as individuals' acts with a focus on developing self-knowledge. Little attention has been paid to how quantification structures the relationship between people and numbers in virtual teams.

We study quantification in virtual teams in League of Legends (LoL), currently one of the most popular multiplayer online games in the world with more than 100 million monthly active players [76]. LoL's API supports numerous third-party websites to obtain rich data about and establish profiles for every single player. Players can use these quantification tools to closely monitor their own as well as their teammates' numerous gameplay aspects such as gaming history and in-game performance. Drawing from an ethnographic study including participant observation, collection and analysis of player online discussion, and semi-structured interviews, we describe how players quantified themselves and others in the context of virtual teamwork. Quantification has become an integral gameplay component as players ascribed authority to performance-based numbers and constantly performed evaluations of self and others. However, the interpretation of numbers was inherently flexible, relying heavily upon players' situated knowledge of the game and the community. Quantification also intensified virtual teamwork as players frequently quantified and passed judgments on others, including teammates and opponents. Players also experienced stress and anxiety associated with their perceived misuse of quantification. Based on these findings we discuss the complex relationship between quantification, self-knowledge, and virtual teamwork.

Our contributions to the CSCW literature are three-fold: First, we deepen the understanding of quantification by describing a highly developed culture of quantification in a community where all the members' data has been public available, calculated, and analyzed across multiple years; Second, we contribute to studies of virtual teams by discussing the use of quantification in virtual teamwork; Third, we analyze how quantification mediates collaborative play in online gaming.

2 BACKGROUND

League of Legends (LoL) is a multiplayer online battle arena (MOBA) game developed by Riot Games located in Santa Monica, California, United States. It is currently one of the most played games in the world with reportedly 100 million monthly players around the world [64]. Its annual eSports World Championship hosted by Riot Games attracted 60 million people in 2017 [50].

LoL's core gameplay style is to arrange a five-versus-five match. Prior to the start of a match, each team of five players would first enter the "Champion Select Lobby," where they meet each other for the first time, discuss later gameplay strategies, and select a champion out of more than 130 available champions in LoL. A typical match lasts between 20 minutes to 50 minutes. Two teams are generated from a large pool of available players based on their skill, measured by

matchmaking rating (MMR), so as to create a balanced match[2]. Given the massive player base, players assembled into a team rarely know their teammates, and must cooperate with the other four strangers within a short time. An exception is that a player can "duo" with one friend, but the rest three teammates are strangers. Previous work on LoL has found that these pickup groups, or temporary teams, face enormous challenges in creating smooth cooperation, and conflicts and tensions could easily erupt [43,48,71].

While MMR is what Riot Games considers as the true skill rating of a player, it is not visible to players. LoL has two game modes: normal and ranked. In this paper, we focus on players practices related to the ranked mode. Only in the ranked mode does LoL use a league system to rank and represent players' skill level. This skill representation is visible to players. The league system consists of seven leagues, including Bronze (22.06% of all the players), Silver (49.54%), Gold (19.69%), Platinum (7.18%), Diamond (1.43%), Master (0.05%), and Challenger (0.02%)[3]. Each of the first five leagues also contains five divisions, each of which has 100 league points (LP). Players accumulate or lose LP by winning or losing matches. Upon reaching 100 LP in a division, the player enters a promotion series of several matches that determines whether the player can be promoted to the next division. Players can be demoted to a lower division if they reach 0 LP.

Through the past few years, the LoL game client had intermittent support for the display of player performance-based data. In Patch 8.15 released in July 2018, the LoL client added a new feature named "stats" displaying a wide range of performance-based data. By the time of this study, players have relied upon third-party quantification tools that collect and analyze data from LoL's API to gauge player performance. LoL players use these tools to monitor their own gameplay history [46] and inform their collaboration with teammates [44].

Players can encounter discussions or recommendations of these apps in player online communities and websites related to the game, such as LoL eSports teams' official websites. For instance, in a blog published on the website of the eSports team dignitas[4], more than 80 tools were listed and analyzed. The first tool, for example, is described as "Mobalytics - A personal performance analytics tool for League of Legends that gives detailed visualized data on all aspects of your play."

Figure 1 is a screenshot of one of the most common tools (http://op.gg) that players use to learn about their and their teammates' performance. As shown in Figure 1, for each single champion that a player has played, the statistics include the number of matched played with the champion, win rate of each champion, kill/death/assist ratio (KDA), average gold, average creep score (CS), an MMR score predicted by the tools, and so forth. Besides the information in this screenshot, op.gg is highly developed with numerous tabs leading to a wealth of information regarding different aspects of a player's current and past performance, such as win rate in the past seven days and top played champions.

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[2] Official Explanation from Riot Games at: https://nexus.leagueoflegends.com/en-us/2018/02/dev-matchmaking-real-talk/

[3] Percentages collected on March 2, 2018 from http://na.op.gg/statistics/tier/

[4] http://team-dignitas.net/articles/blogs/League-of-Legends/9966/a-complete-list-of-league-of-legends-tools-sites-to-improve-your-game
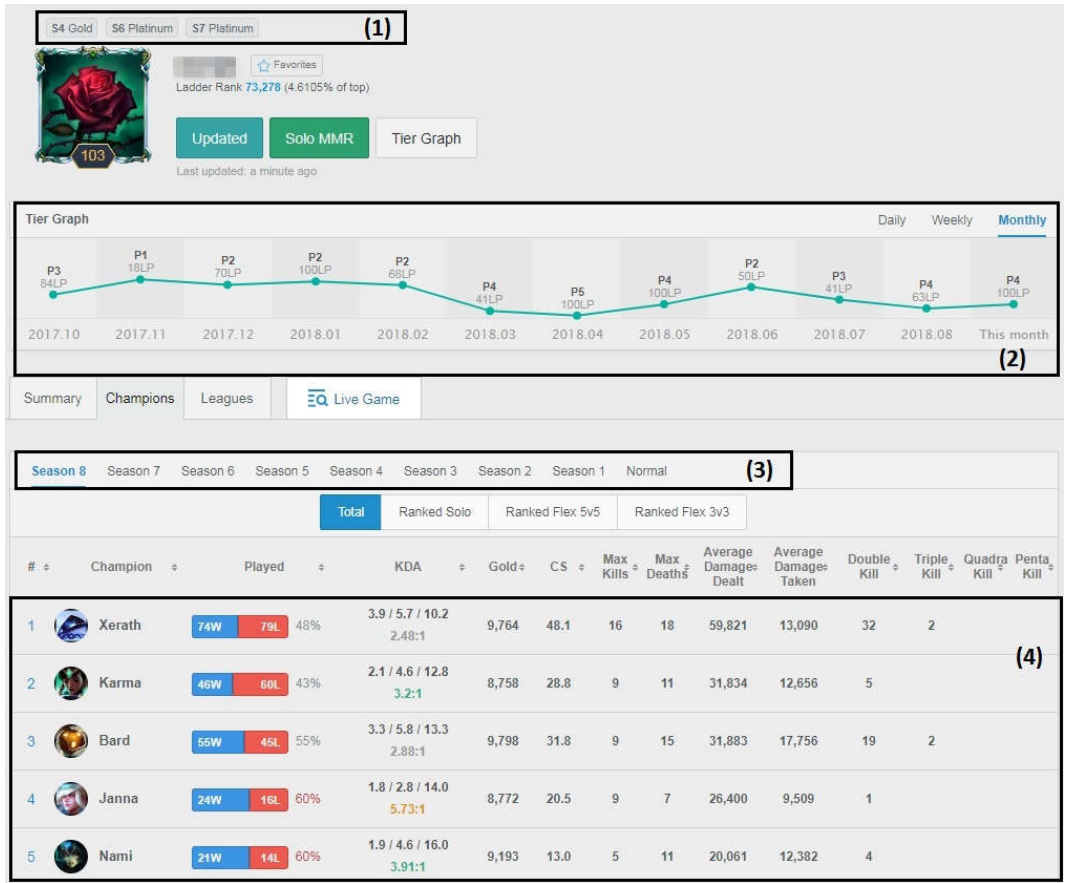
Figure 1. Screenshot of the first author's gameplay profile on op.gg (taken on September 15, 2018). 1) Player ranks in the past several seasons in 2014, 2016, and 2017. 2) Player ranks in each month from October 2017 to September 2018. 3) Tabs for gameplay data from season 1 in 2011 to season 8 in 2018. 4) A partial list of all the champions played in season 8 and rich gameplay statistics.

3 RELATED WORK

3.1 Knowing through Quantification

Quantification is a "constitutive feature of modern science and social organization" [26]. It prevails in increasingly more aspects of our contemporary society such as manufacture, education, politics, economics, and health. It can also be viewed as a form of "technique" in Jacques Ellul's term that is "rationally arrived at and having absolute efficiency (for a given stage of development) in every field of human activity" [23].

Particularly, self-quantification as a technique to develop knowledge about the self has been often traced back to Foucault's writings on the ethics of care of the self [53]. For Foucault, individuals should constantly engage in a moral and ethical project to achieve happiness, wisdom, health, and wellbeing [27]. When Foucault conceived the idea of self-knowledge and care of the self [27], he pointed to individuals' agency in developing knowledge about themselves against the backdrop of the prevalence of power relations. Foucault further discussed technologies of the self through which individuals could develop self-knowledge, such as self-examination with respect

to thoughts in correspondence to reality, the way our thoughts related to rules, and the relation between the hidden thought and an inner impurity [28]. Building upon the idea of technologies of the self, researchers have explored how digital technologies could become a technology of the self as people exert their agency in discovering and transforming their selves [41,52].

In personal informatics, one primary application field of the practices of self-quantification, individuals collect, analyze, and reflect upon many types of personal information such as bank statements, email history, and health information [49]. Particularly in self-tracking, individuals start to quantify and monitor themselves for many reasons such as better health condition, physical or mental performance, new stimuli, or socializing [12,53].

But numerical representation, the output of quantification, has long been cited for issues such as a reductionist approach [65,66], removal of contextual information [21], and complex psychological processes related to interpretation of the data [11]. Ultimately, quantification entails categorization and involves qualitative judgment [10,14,63], demanding closer attention to the entanglement between quantification and the values beneath design decisions [7].

Inspired by John Langshaw Austin who analyzed words as deeds [3], Espeland and Stevens suggested that numbers should be regarded as deeds as well [26]. According to them, numbers are acts of communication whose meanings and functions depend deeply upon 'grammars' and 'vocabularies' developed over time through use, and should not be reduced to a narrow instrumentality [26]. They proposed one important distinction between forms of quantification which is those that mark and those that commensurate. Numbers that mark are used to identify entities, such as numbers on a license plate. Numbers that commensurate are to evaluate or measure different objects with a common metric [25]. For Espeland and Stevens, commensuration is a process that creates a specific relationship among objects by transforming all difference into quantity, thus requiring considerable social and intellectual investment [25]. Measures can thus influence and discipline people, or shape and reinforce existing categories [26]. Therefore, quantification can have multiple meanings and purposes across contexts. To understand a specific form of quantification, we shall study the context through which numbers are generated, sorted, and interpreted through numeracy and broadly shared methodological standards.

3.2 Trust and Collaborative Traces in Virtual Teamwork

Understanding challenges and design opportunities for supporting virtual teams has been a primary research strand in both CSCW and organizational studies for a long time. An important foundational element for successful virtual teamwork is trust. Tseng and Fogg considered trust as "a positive belief about the perceived reliability of, dependability of, and confidence in a person, object, or process" [75]. In virtual teams, members may not have a history of interpersonal interactions and communication through which trust is developed in collocated collaboration. Thus organizational and management research has explores many facets of trust formation in virtual teams, such as managers' and leaders' strategic actions [30], goal setting [35], the interplay between the cognitive and affective dimensions [40], functional diversity [62], and the relationship between monitoring and trust [18,67].

To foster trust in virtual teamwork, a rising body of CSCW research, often focused on the setting of global software development, has turned to mechanisms that support teammates to follow and monitor one another's work status and history. For example, Froehlich and Dourish implemented a visualization system that provided a view of the dynamic software process, and reported that this system providers developers meaningful information and context of development process [29]. Marlow et al.'s qualitative investigation of GitHub, an online software

development community, reported that activity traces such as history across development projects could inform how people assess expertise and shape social interactions [55]. Regarding these various mechanisms, Trainer et al. discussed the notion of "collaborative traces" [74], which refer to representations of the past and current activity of a group of virtual teammates. Trainer et al. showed that tools that adopt collaborative traces could support the development of trust [74]. Similar to the idea of collaborative traces, quantification tools in LoL used a rich set of numbers to show teammates' past and current gaming activities. In this paper, we examine how collaborative traces intersected with LoL players' trust in their virtual collaboration.

3.3 Participatory Surveillance in Online Games

As players use quantification tools to monitor both their and their teammates' performance, quantitative measures support simplifying, classifying, comparing, and evaluating, the core means of disciplinary power [69]. Particularly, LoL can be analyzed from the lens of "surveillance games," which Albrechtslund and Dubbeld defined as ones "that use data processing technologies to provide or enhance entertainment, thereby appropriating surveillance devices for their own hedonistic purposes" [2]. Later Albrechtslund proposed the notion of participatory surveillance [1] to argue for the social and playful aspects of surveillance, which has been less discussed in previous surveillance literature that focuses primarily upon the negative and repressive aspect of surveillance.

However, video games are not just for play, entertainment, and relaxation. Yee noted that video games blur the boundaries of work and play as online games players invest lots of time (average 20 hours a week), perform "an assortment of clerical tasks, logistical planning and management," the very same thing they do in their offices [80]. Extensive video game research has reported how players carried out systematic and carefully planned efforts in order to make progressions and achievements [4,44,57,72]. Video game research in the CSCW literature has developed a deep understanding of video game play as a form of collaborative work [37,58,59].

Putting together the idea of participatory, playful surveillance and that of the blurring boundary of work and play, we observe a tension between the pleasurable and the serious, work-like framings of monitoring self and teammates. Stressing the importance of willingness to participate in surveillance, Whitson noted that "the moment you understand that you are working, you are not playing... But for it to be experienced as play, everyone needs to be a willing participant" [79]. LoL players cannot be considered as "willing participants," as the game company, Riot Games, owns and decides to make available players' data. In this regard, our paper contributes to a deeper understanding of the relationship between work and play in the context of surveillance practice.

4 METHODS

This paper is based upon a multi-year ethnographic study of League of Legends from October 2011 to the time of this study. The ethnographic project was initiated with a general purpose of understanding players' social experiences within the game community. The project has gradually developed into two distinct but related strands including governance [45] and player experience [43,44]. This paper belongs to the second strand. The first author conducted participant observation in the game's North American server as well as numerous related online venues, following the idea of multi-sited ethnography [54]. The first author played between 700 to 1000 ranked or normal matches per year since 2011 (except the year of 2015), ranked at Platinum by the time of this study, and participated in and observed player discussions in LoL-focused online

forums hosted on Riot Games' server as well as general social media sites such as Reddit. The first author also frequented video-based social media platforms such as YouTube and Twitch, a living streaming site, which were frequently discussed among players as primary venues for watching and learning from the gameplay of professional eSports or highly skilled players. The first author obtained knowledge of these quantification tools through this long-term engagement in the game, and frequently used these tools to inform his own play. Extensive fieldnotes and screenshots were taken regarding numerous aspects of social life and player experience with the game through participant observation.

The project was not about quantification from the very beginning. While doing ethnographic work, the first author also conducted two rounds of interviews prior to this study of quantification. The first round was conducted in 2012 and 2013 with a focus on how player perceived collaboration in LoL. The second round was conducted in 2014 and 2015, concerning how players learned and improved their ranks in game. Both served as individual research projects. It is important to note that the first two rounds prior to this study did not have a focus on quantification. However, the opening questions such as how you improved your skill in the game often encouraged players to talk about their experiences with numerous quantification tools that they had used, with op.gg being the latest and most frequently cited among the study participants. The first two rounds of interviews, as well as the first author's own experience, inspired this study to investigate how LoL players used quantification in their play.

The latest round of interview was conducted in February and March 2018, with a focus on the use of quantification tools in gameplay. During this round, we conducted semi-structured, open-ended interviews with 22 LoL players with diverse ranks distributed across Bronze, Silver, Gold, Platinum, and Diamond. They all reported playing for at least one year and being familiar with one or more quantification tools. The interviews were started with the following open-ended questions: 1) can you talk about when you started playing the game? 2) how do you improve your skill in the game? 3) how did you come to know the existence of the quantification tools? 4) when do you use these tools? 5) how do these tools influence your gameplay? 6) how do you know other players use these tools?

The interviews were conducted either through in-game messaging function, email, or skype in English, and lasted between 20 and 40 minutes. We manually transcribed these interviews for later analysis. Combining previous interviews where players mentioned their use of quantification tools, and the latest round of 22 interviews focused on these tools, we had a total number of 68 interview transcripts. A substantial portion of the 68 interviews mentioned quantification. However, when reporting data in this paper, we draw primarily from the latest round of 22 interviews, as well as one from an interview conducted in 2015, because of their data richness and topical relevance. Due to the limit of space, Table 1 only introduces the demographic information of 23 participants whose interviews were actually used in this paper.

We used thematic analysis [6] to analyze our data in an inductive approach [61] to identify themes that are strongly linked to the data themselves. The dataset for analysis included all the 68 interview transcripts, as well as forum discussions, fieldnotes, screenshots taken in the past few years. Two researchers (including the first author) familiar with LoL participated in this analysis process. We first familiarized ourselves with data with the initial analytic interests in the role of quantification in supporting gameplay. Each researcher immersed himself or herself in the data through reading back and forth and marking ideas. During this iterative process, the two researchers had regular meetings on a daily basis to discuss ideas. Each of us then started generating an individual list of initial codes through our whole dataset, after which we compared

and combined our initial code lists through discussion. Following the suggestion of coding for as many potential themes as possible [6], we generated over 290 codes. An example is the data extract "Looking at op.gg is good if you use it correctly" which was coded for "positive review of quantification" and "knowledge about how to use." After generating the initial code list, we refocused our analysis at the broader level of themes, using rounds of discussions to consolidate our codes into an overarching theme. During this process, we also went back and forth between the generated themes and the dataset to refine the themes, with the goal of ensuring internal homogeneity and external heterogeneity [61]. Our final satisfactory thematic map includes three primary themes: how players developed knowledge through their situated interpretation of numbers, how players used their interpretation of numbers to improve performance and make gameplay strategies, and their reflections on the negative aspects of quantification and what constitutes proper relationship with quantification.

Note: Player rank information was collected by the time of interview. In recruiting methods "unfamiliar contact" refers to the situation that the first author and a player added each other on their contact lists for a long time, but there was no communication between them. This pattern is common within the LoL community, where players simply send a friend request to whom they just played with or against. Many players have a long contact list containing hundreds of players, but are not in active contact with the majority of the contact list. P23 was interviewed in 2015 before the latest round of 22 interviewees. "N/A" means the interviewee did not disclose this information to us during the interview.

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Table 1. Participants' demographic information.

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	Age	Gender	Years in LoL	Years of using quantification	Player rank	Recruiting methods
P1	22	M	6	4	Silver	Direct contact
P2	19	M	2	1	Gold	Unfamiliar contact
P3	N/A	M	4	4	Platinum	Unfamiliar contact
P4	24	M	4	3	Platinum	Direct contact
P5	N/A	F	3	2	Gold	Unfamiliar contact
P6	20	M	7	5	Platinum	Direct contact
P7	21	M	5	4	Gold	Snowball sampling
P8	28	M	6	6	Gold	Unfamiliar contact
P9	28	M	5	3	Silver	Snowball sampling
P10	22	F	4	3	Silver	Snowball sampling
P11	24	M	3	1	Silver	Direct contact
P12	29	M	6	6	Diamond	Direct contact
P13	19	M	5	3	Silver	Unfamiliar contact
P14	20	F	4	1	Silver	Snowball sampling
P15	22	F	2	1	Bronze	Snowball sampling
P16	24	M	4	3	Platinum	Unfamiliar contact
P17	26	M	5	2	Silver	Direct contact
P18	23	M	3	3	Gold	Unfamiliar contact
P19	N/A	M	4	4	Gold	Direct contact
P20	N/A	M	5	4	Platinum	Direct contact
P21	24	N/A	3	3	Silver	Unfamiliar contact
P22	N/A	N/A	4	3	Bronze	Snowball sampling
P23	N/A	N/A	2	N/A	Gold	Forum recruiting

When reporting interview quotes, we use P1, P2, etc. to denote different study participants. We have obtained the IRB approval from our institution prior to collecting and using online data for this work. In considering ethical concerns [9], when reporting online data, we paraphrased quotes from forum discussions to disguise the data and reduce their searchability.

5 FINDINGS

League of Legends players used various quantification tools to quantify themselves as well as others for the purpose of progression in the game. Players frequently engaged in interpretation and re-interpretation of their numbers, as well as negotiation of numbers' meanings in team communication. Quantification and interpretation involved much cognitive work and invoked emotional reactions, and sometimes disrupted virtual teamwork. Some players reflected upon what constituted proper use of quantification.

5.1 Nuanced and Situated Interpretation of Numbers

LoL players acknowledged the great diversity in the numbers provided by the quantification tools. They, however, stressed that numbers were not self-evident. Players saw various meanings and implications of numbers. They tried to interpret numbers by drawing from their situated knowledge in LoL.

5.1.1 Capturing Various Meanings and Implications of Numbers

We observed that numbers were frequently cited as markers of skill and performance. Each participant that we interviewed had developed standards for determining the meaning of a number. For example, a participant told us:

I had 85% win rate on Ekko [a LoL champion], it was amazing... until they [Riot Games] made the changes [new game patch] to remnants of the watchers [an in-game item]. My KDA [kill/death/assist ratio] before the changes were 4.50. [P1]

In this quote, P1 explained how his numbers associated with Ekko were negatively influenced by LoL's recent patch. He also expressed high satisfaction with his previous records associated with Ekko, where he considered '85% win rate' and '4.5 KDA' indicators of good performance.

In a similar vein, P2 asked us to visit his op.gg profile by saying "*check my lux [a LoL champion] win rate on op.gg... over 60%!*" P3 told us that "*200 CS [creep score] in 20 minutes... it is my best record.*" In these cases, numbers that fell within certain ranges had supplied players joy and pride, because these numbers were considered both "good" and difficult to achieve.

According to our study participants, numbers did not just represent gaming skills. They could also reveal other qualities such as temperament, mindset, motivation, and desire to win. For example, a participant noted how she sometimes could discern players' mental stability:

If you see a player on a massive loss streak like 1:8, likely that the player is tilted... Your game is not going to end up well. [P5]

"Tilt" or "tilted" means that a player's mental state is declining, which is likely to negatively impact player performance. For P5, the numbers of wins and losses in the recent match history of a player did not simply communicate the player's previous performance. The numbers also strongly suggested the likelihood of the player's chance to win in next match. Many of our participants expressed a similar viewpoint with P5 that a player who was experiencing or had just experienced was likely to do badly in game. Beneath this logic was players' many personal experiences with a "vicious cycle," that losing a game caused negative emotions such as distresses and frustrations, which in turn impacted their future games in negative ways.

5.1.2 Interpreting Numbers in Light of Situated Knowledge

Our participants stressed that situated knowledge of the game was key to proper interpretation of numbers. One type of situated knowledge of the game commonly cited by our participants is the knowledge regarding the different modes of the game. P7 said:

> *A high KDA in normal is nice, but it says little about skill... [players] don't try hard in normals. [p7]*

"Normals" refer to the normal game mode that is not ranked, in which players tend to be more casual. In normal mode, players tended to try new play styles and care less about winning, and high KDA could happen because the player was trying powerful champions while others weak ones. Experienced players like P7 were acutely aware of the distinction between the two game modes, and utilized this situated knowledge to make more accurate assessment.

Another type of situated knowledge of the game frequently brought up by our participants is the knowledge of different champion's mechanism. When asked what "win rate" would look good, P5 explained:

> *It depends on the champion... I have above 55% win rate with Zyra [a LoL champion] and generally feel like I'm carrying with her... but a Yasuo [a LoL champion] below 60% win rate is bad. Yasuos either solo win the game... or feed and ruin the game. [P5]*

In LoL, Zyra and Yasuo have different play styles, with the latter being high-risk, high-reward. Therefore, Yasuo's impact on match results tends to be highly polarized. With knowledge of different champions, P5 had developed more situated interpretations taking into account different play styles associated with champions. In this way, a number like 55% win rate could have different meanings per context. In addition, P5's explanation indicated how she gradually learned how to interpret numbers through her own experiences. Her general observation that she contributed a lot to teamwork (i.e. "carrying") was an important reason behind her belief that 55% was a good number for Zyra. Similarly, her experiences with Yasuo teammates deeply influenced her interpretation of Yasuo win rate.

In addition, our participants also stressed that gameplay across the wide spectrum of ranks was vastly different in terms of player decision making, team composition, and competitiveness. Therefore, they described how their understanding of these differences influenced their interpretation of numbers. For example, P14 told us:

> *My Diamond friend dies averagely 6-7 times...he said he had to takes risks... [but] he almost never dies playing on my account [in Silver]. [P14]*

P14 narrated a sharp distinction between Diamond and Silver, and how such distinction in gameplay could result in different numbers: Diamond matches are more competitive and intense, leaving little room for players' decision making. Therefore, P14's friend could perceive more risks when playing at Diamond. However, the same player encountered few challenges at Silver, and thus "almost never dies." P17 remembered that his average CS decreased as he climbed from Gold to Platinum, because he encountered more *"aggressive lane opponents"* that would prevent him from getting more CS. Like P14 and P17, many of our participants noted how the intensity and competitiveness of different ranks could influence numbers.

Through playing LoL, players kept learning about various aspects of LoL that would offer new angles to interpret numbers. Each player' set of situated knowledge was gradually built upon their own experiences. Therefore, the derivation of qualitative insights from numbers was cognitively challenging to many players. Online forums became a place where players learned from each other about how to interpret numbers. We learned about this social activity on the '/r/leagueoflegends' subreddit from several of our participants. Here is an example:

> **Post:** *Post a link to your OP.GG profile and get advice from the community!*
> *I believed it could be nice if high elo players could share some advice to low elo scrubs like myself :)*
> **Player 1:** *My CS is trash [shared link to a op.gg player profile; removed for anonymity]*
> **Player 2:** *Miss fortune [LoL champion] and Ashe [LoL champion] were good picks for your rank. But you should consider playing more Annie [LoL champion] instead of Orianna [LoL champion]. This way you can both improve CS and focus more on the game rather than csing.*

Elo is an alternative term for player rank. In this excerpt, Player 1 invited critique upon their own profile. While Player 1 expressed one of their numbers (i.e., CS) was poor, Player 2 gave concrete advice on improving CS as well as more general suggestions regarding how to improve skill. Player 2's analysis was based on a combination of Player 1's numbers as well as Player 2's understandings of different champions' strengths and weaknesses.

5.2 Using Quantified Data to Strategize Gameplay

Through the interpretation of publicly available data, LoL players conveniently reflected on their own performance, and learnt about their teammates and opponents. They used this knowledge to inform their gameplay. They could coordinate with their teammates to optimize their gameplay strategies.

LoL players' reliance on quantification for gameplay was manifested in a common linguistic pattern in the community. We observed numerous instances where terms denoting quantification tools such as 'op.gg' and 'lolking' were used as not only nouns but also as verbs. Players frequently used "op.gg me" or "lolking the player" to denote the practice of checking someone on specific quantification tools. An example is *"If you op.gg me, you can see I win almost 70% of my Jarvan IV [a LoL champion] games."*

5.2.1 Developing Self-Knowledge and Improving Performance

As players believed that these numbers indicated their own performance and skill, they took advantage of the quantification tools to develop insights into their own gameplay. P1 told us that *"I mainly use op.gg to check my KDA, win rate, and …. I just like to track my progress to get better."* In this way, players sought to develop self-knowledge through quantification. On Reddit, a player shared their op.gg profile, and narrated a story of progression through numbers:

> *Just climbed from Plat 4 to Diamond 5 playing only Fiddlestick (86% winrate over 28 games) [shared link to a op.gg player profile; removed for anonymity] … started tryharding with my beloved main and had this massive win streak (24 W - 4 L).*

"Main" refers to the champion that a player plays the most. In the above quote, the player's main was Fiddlestick. The player expressed excitement about improvement in the game.

All of our participants mentioned using quantification to keep informed and seek self-improvement. For instance, P11 said:

> *My Janna's [a LoL champion] KDA was embarrassing with 5.1 deaths per game… because most jannas have less than three deaths. My janna died too much because I played in a wrong way… I watched guides to learn builds, matchups, and itemization.*

According to P11, his interpretation of his Janna KDA was that his performance was poor and he needed improvement. He proceeded to learn and improve himself.

5.2.2 Assessing and Choosing Teammates

Participants used numbers to observe the status and skill level of their friends. They then used this observation to invite skilled friends to play together. For example, P4 said:

I have made some friends in league...I would look them up [on quantification tools]. I know their best roles in the game... who I want to duo [playing with a friend] with for my placements...who I only play norms [normal mode] with. [P4]

P4 shared with us how he used quantification to develop knowledge about his friends. Placements refer to placement matches that have a major influence over players' rank. Building on the knowledge of his friends, P4 would strategize his play for the purpose of progression in game. In competitive matches, especially placements where stakes were higher, he wanted to play with friends who he believed to be highly skilled. In casual scenes, he would be more open to playing with friends of different skill levels.

Players could perceive whether their teammates desired to win through interpretation of numbers. For example, P10 said that "you know your teammates don't want to win when they pick a champ they are bad at. Chances are you already lost in champion select."

Players also mentioned how numbers told them whether their teammates could be potentially toxic in game. In an interview via the in-game messaging tool of LoL client, P1 sent the URL to an op.gg profile and said:

Just check this guy. His Teemo [a LoL champion] has over 8 deaths each game with only two or three kills... Those players just feed and flame junglers [a role in game] all time. When he locked in Teemo, I insta dodged."

"Dodge," or "queue dodge," refers to the action of closing the game client to cancel a match. Dodge is not against LoL's terms of service, but it wastes the computing resources for generating a match and causes delays to other players. Riot Games discourages this behavior by deducting a small amount of ranking points per time of dodge, which is less consequential than the decrease of ranking points if losing a match. Therefore, players would calculate benefits and risks when deciding whether to dodge. Without actually playing the game with his teammate, P1 was already confident in telling about a teammate's potential negative behaviors in game. Interpretation of the numbers associated with Teemo suggested the teammate's potential poor performance in the next game. Such interpretation, combined with past experiences with Teemo players, supported P1's reasoning process leading to the conclusion that his teammate could be a toxic player that he would avoid teaming up with, and thus he decided to dodge the game to avoid the risk of losing ranking points.

5.2.3 Negotiating with Teammates

Participants used their numbers as evidence to support their verbal claim for certain roles in team. P13 shared his story with us:

In champ select lobby I would say can I mid? I'm really good at a couple ap carries [roles in game]. You can look me up on.gg. Then I tell them I couldn't do anything else... I also paste my op.gg link so they can click. Sometimes it works, my teammates would give their role to me... not every time though. [P13]

In this example, P13 talked about how he shared his profile with his teammates in order to convince his teammates that he should play the role of mid[5]. Quantification here was used to enhance the legitimacy of his claim. For this use of quantification to work, the player must be aware of the generally accepted criteria, or the common ground, for determining high or low performance of particular champions and roles. Having experienced similar situations but on the other side, P7 told us that *"I use op.gg when someone is asking for my role. If they have a good win*

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[5] There are five roles on a team: top, jungle, middle, bottom, and support. The "Middle" role's typical function is to deal lots of damage.

rate with champions in that role, that's fine. But if someone wants to mid with a 11% Kass [a LoL champion], then I'm sorry."

Players also used quantification to persuade their teammates into certain actions for perceived better winning chances. A player wrote on the official forum that:

I use it to try to encourage teammates to play the champs they are actually good with…For example, I would say: o? you have 227 games with jinx [a LoL champion] adc and a solid 68 percent wr and are instead deciding to just try out vayne [a LoL champion] adc with 10 games and 20 percent win rate?…DAMN MAN YOUR JINX IS SEXY AS FUCK!…they will likely pick jinx just to show how sexy their jinx is XD

In this excerpt, the player vividly described a scenario where they tried to persuade their teammate to pick a champion that the latter was good at, evidenced in the combination of number of games and win rate. For this player, these combined measures unambiguously pointed to a much better qualitative choice in champion selection. Therefore, the player took action for the purpose of improving their winning chance.

Lastly, quantification supported them to strategize their gameplay for the best chances of winning games. Most of our participants looked up their teammates and used this knowledge to customize their play style. For example, P12 told us that:

As a jungle [a role in game] main, I found op.gg extremely useful… I had a game with Nasus [a champion] top. He had 75% win rate over 45+ games. I knew if I could give him a good start, he would be able to snowball and carry the game. That's what I did. I came to his lane right after my red buff and gave him a kill…. He and I carried the game, even though other lanes were a bit behind. [P12]

The jungle role in LoL is a leadership role, requiring the player to decide which teammates to help with and what objectives to pursue for the best outcome. For P12, the analysis of his teammate's statistics informed his play style. The subsequent win confirmed his previous theory about how to strategize gameplay based on interpretation of teammates' numbers.

5.2.4 Exploiting and Constraining Opponents

Our participants talked about various ways of drawing from quantification to tailor strategies to constrain their opponents. On the one hand, P17 told us that *"I'm gonna try hard to not lose to my lane opponent who is having a losing streak."* In this example, P17 described a scenario where he noticed his lane opponent's losing streak, and surmised that his lane opponent might be "tilted." P17 wanted to take advantage of this perceived weakness of the lane opponent.

On the other hand, players could perceive their opponents as skillful and superior. This perception encouraged players to adjust their play styles to be more conservative. Here is an excerpt from an online forum conversation:

If I see they have 300 games played with said champ in rank, I know they're at minimum experienced. If I see KDAs that go along the lines of 15/4/10 for that champ after an average of 10+ games, I know to play safe, because that user has proven to be good with that champ multiple times.

Here the player listed several convincing numbers such as "300 games" and "15/4/10," which indicated a strong opponent. In such case, the player made the decision of "play safe," meaning the adopting of a low-risk play style.

Besides adjusting individual strategies, quantification of opponents also supported coordination between teammates. For example, P18 said that *"I'm currently gold 3. If I know my opponent is plat 5, I will ask my jungler to camp my lane."* Camp describes a tactic that a player

stays close to their teammate without being noticed by opponents. The camper could then surprise and kill opponents with ease. When P18 noticed the quantified rank difference between him and his opponent, he expected his opponent to be more skilled than him. Not wanting to lose on his role, he would coordinate with his teammate to constrain his opponent in game.

Players shared with their teammates what they learned from quantification of their opponents, so that the whole team could be mindful of the opponent team's unique strengths. P19 noted:

I can tell who is good on the enemy team. I would warn my team, especially if there are smurfs [new, low ranking accounts owned by high ranking players] on the opposing side. We can make a plan to shut them down early so they don't get to carry the game. [P19]

P19 explained how he helped make gameplay strategies based on his understanding of the opponents. He first made an inference about whether his opponent was a smurf. He could notice if a player's numbers were unusually stronger than average players in his rank. This knowledge informed how he strategized his gameplay.

5.3 Negotiating with Quantification

In the first two sections, we reported how LoL players sought to rationalize and utilize their interpretation of numbers, for the purpose of progression in game and optimization of teamwork. However, beyond the rational and instrumental use of quantification, players also had emotional investment into their numbers. We observed that many players struggled to strike a balance between their amount of attention to their numbers and just having "fun" in game. Many of our study participants mentioned what constituted the proper use of quantification.

5.3.1 Experiencing Negative Consequences Associated with Quantification

Our study participants stressed that using quantification was useful in competitive play, and they felt the social pressure to do so. P11, for instance, stated that:

I have to use these tools to compete with people who already use them... it is publicly available and whoever doesn't use it is at a disadvantage. [P11]

From a practical point of view, P11 stressed how quantification was already an integral component of ranked gameplay in LoL. As an individual, he could only comply with this practice to keep up with other LoL players.

Our study participants also perceived various negative consequences associated with their use of quantification. At the individual level, misuse of quantification could cause negative emotions such as distress and anxiety among players. At the team level, discussions of numbers could cause conflicts and tensions.

Stress and Anxiety among Individual Players

Players viewed numbers as direct indicators of their performance, and developed judgements as to what numbers were superior. Pursuit of better numbers became their conscious goal while playing games. For instance, P6 mentioned that *"I try to keep my deaths under 4 each game. Good players don't die a lot."* Like P6 said, qualitative marks such as "good players" were consciously related to a specific numerical range. Poor numbers, on the other hand, could cause negative emotions among players. P14 told us that *"I have an embarrassing win rate with Dr Mundo... under 40%... I'm terrible with tanks."*

The attention on numbers and improving numbers also caused much stress and anxiety among several participants. P19 told us:

Most times I'm good... But it was so stressful when I noticed that my recent win rate has dropped below 40%... I feel I suck at this game. [P19]

As P19 articulated, undesired numbers (low recent win rate) could cause stressful experiences for him.

As many players were concerned with their numbers, some of our participants mentioned the practice of KDA padding, similar to stat padding in sports where players focus on activities of improving their statistics that do not contribute to actual results. P8 said:

No one would admit it but you know it exists... yesterday they [the enemy team] were winning so hard that they could end the game any time, but they didn't kill the nexus [totally destroying the enemy base and thus ending game]. They just kept killing us when we came back alive. [P8]

In this example, P8 suspected that his five opponents were padding their KDAs, drawing from his observation of a mismatch between the opponents' overwhelming advantage in game and their unwillingness to end the game. He also suggested certain level of social stigma associated with this kind of behavior, as such behavior does not align well with the competitive eSports culture that both the player community and Riot Games valued. One of our participants, P9 expressed strong disdain for KDA padding, saying that *"KDA players just stupidly ignored objectives like turrets and dragons... They are after kills."* A player on Reddit suggested a more nuanced view towards KDA padding, saying:

KDA padding is always fun, if you're into that kind of stuff (as do I). However, practically speaking it can often be a poor indicator for general performance... A kill on a specific opponent becomes less significant for the gold bounty. After you have done with the maths, it doesn't make as much of a difference in your economy as you think it does, compared to other play style.

"Gold bounty" is the virtual reward for killing an opponent. In this excerpt, the player suggested that number could become an end in itself, because better numbers were desirable. However, an overemphasis on numbers was said to have an adverse effect on decision-making in game, when players favored strategies that could improve their numbers instead of those that could help win the match. In this way, the player indicated that the existing set of statistics did not fully align with the actual effects of particular in-game actions, and therefore players should be cautious when using these statistics to prescribe their actions.

Conflicts and Tensions within Teams

Participants also mentioned checking their teammates, and sometimes became unsatisfied by teammates' numbers. Such dissatisfaction could surface in communication with teammates, causing conflicts and tensions within teams. For example, P21 mentioned:

I was constantly checking both teams on op.gg. I found it actually hurt my mentality going into the game believing that your team is gonna suck. I could easily start flaming my teammates for small mistakes, and I became the biggest reason my team lost. [P21]

P21 described how frequent use of quantification started to incur negative consequences over his in-game mood and make him distressed. In some matchups, through interpreting teammates' numbers and predicting match results prior to the start of the match, he already foresaw a loss and attributed it to his teammates. Such practice would negatively influence teamwork as he became intolerant to teammates' "small mistakes," which in turn contributed to a loss. Similar experiences were discussed on Reddit, where a player wrote:

Checking stats is tilting for many. If you're prone to stat anger, you should just block all those websites in your browser. There is useful info there but avoid it if you can't control focusing on what actually may be useful in it. If you are busy calling out people about previous games and why their itemization is wrong according to the pros, you are not focusing on your playing or the game you're in.

"Stat anger" refers to players' self-perceived anger triggered by finding out teammates' poor statistics. The above quote suggests that players who are likely to grow negative feelings should stop using quantification. The quote further explains that when players become aggressive towards teammates because of their poor statistics, they are not focusing on the right things (themselves and the game).

Players also mentioned their negative experiences with being judged based on their numbers. Our study participant P15 complained that *"teammates abused me very early on saying that my KDA was bad. It is unfair to judge me like that. The game is teamplay-based."* As P15 described, her teammates harassed her because they determined her numbers to be poor. In this way quantification actually intensified disagreement between teammates, and even helped spur aggressive behavior within team. P16 mentioned a similar incident that occurred between him and his teammates in a recent game. He said that *"I just had a bad nid [a LoL champion] game. My teammates told me something like 'wish you realized maybe you shouldn't play nid after you have a 38% win rate on it over 70 games.'"*

Misuse of quantification could also fuel aggression between opponents. For example, P13 told us that *"if I beat a smurf that brags a lot early game, I would mess around at the end and tease him about his win rate."* According to many of our study participants, most of the time provocations took place when the match result was almost certain. For instance, P20 described:

> One day I was really annoyed by a guy checking my profile and assuming that I was bad. I just straight up beat his ass, follow him everywhere, take all his buffs, and defeat all his ganks. Later in post-game chat I told him that hope 'op.gg people' works for you in future games. That was fun. [P20]

P20 described how both he and his opponents used quantification to provoke each other in game. Such exchange tended to intensify the communication between two teams.

5.3.2 Exploring Proper Relationships with Quantification

Some LoL players perceived the downside of using quantification. They started to stress the idea of using quantification properly. P17, for example, said that *"[you] can't be obsessed with op.gg. It's just a tool. It's only useful if you know what it is and how to use it."* P17 discussed the proper relationship between player and quantification. He noticed the potential psychological burden associated with use of quantification if a player dedicated too much attention to it. He pointed to the instrumental value of quantification, and stressed players' own responsibility and capacity in proper use.

One common way our participants used to cope with the psychological burden was non-use. For example, P6 noted that *"stop using it if it psychs you out."* P6 saw non-use as a way of avoiding negative emotions. Some players reported concrete benefits of non-use. P21 told us that *"I simply stopped. I am feeling much better now and my rank has moved up as well."* Another participant P22 reported:

> I used to check my teammates and got tilted a lot. Nowadays I don't do it any more... I start to focus on my own play because this is the only thing I can control and improve... I learn more each game. [P22]

Both P21 and P22 had been frequent users of quantification. However, they changed their behavior upon noticing the negative aspects of overusing quantification, in order to take care of their own psychological wellbeing. Their descriptions sought to articulate a causal relationship between non-use and subsequent positive experiences, in terms of increased rank and learning.

While non-use was on the extreme end in terms of the relationship between the self and quantification, some players proposed a more nuanced approach. For instance, P23 told us that:

It is very hard to balance. If I use it too much, it starts to get to me... My principle is that I won't bother as long as the team comp looks decent. But if I see some picks that are far from meta [widely accepted champion select strategy], like ashe jungle, I gotta make sure that he is not trolling. [P23]

P23 admitted the psychological toll of misusing quantification. However, he did not simply stop using, or constantly use, quantification tools. He adopted a case-by-case approach with consideration of specific conditions.

6 DISCUSSION

In this paper, we reported an ethnographic account of quantification in the player community of League of Legends. The player community celebrates a highly competitive culture where players aspire to higher ranks, and admire high-ranking players, especially professional players, which has been commonly found in eSports gaming communities [39,44,73,77]. Therefore, it is perhaps unsurprising that numbers and quantification play an indispensable role in this community. The complexity of quantification practices is conditioned by the publicity of every single member's statistics accumulated across multiple years, an abundance of advanced quantification tools, and years of development of a culture of interpretation of numbers. All players are involved, regardless of their willingness. Players who refuse to use quantification are still subject to the quantification, evaluation, and judgment from their teammates and opponents.

In many ways, players' own accounts and forums discussions are in alignment with the ideal of developing "self-knowledge through numbers," as they adeptly used quantification to develop knowledge about themselves as well as their teammates and opponents in order to win matches and subsequently improve ranks. However, quantification could also take a toll on players, both cognitively and emotionally, as players also struggled to find a balance in their relationship with numbers, realizing that improper use of quantification could can distress them and negatively impact virtual teamwork. Next, we discuss implications of the multiplicity of perspectives on numbers, the relationship between quantification and trust, and players' notion of proper use in relation to self-knowledge.

6.1 A Complex Dance Between Interpretive Flexibility and Numerical Authority

Our findings about the nuances and complexities in players' experiences with numbers resonates with Espeland and Stevens that numbers have multiple meanings and purposes [26]. Numbers generated through quantification had multiple meanings to participants. These meanings were constructed based on players' interpretations, experiences, and discussions with other players within the community. The numbers could be an explicit representation of player skill and performance, evident in how study participants took pride in their high win rate champions in interviews. Participants also believed that they could capture many other personal qualities such as mental state and desire to win through scrutiny of statistics such as win rate and match history.

Numbers also possessed multiple types of purposes, which could analyzed as "deeds" [26]. They not only described what a player had achieved in the past, but also advised in-game actions, and predicted whether the player would either succeed or fail in the future. Our findings reported many accounts where numbers inspired players to predict match results and strategize gameplay. In Table 2, we summarize representative types of numbers and their purposes. (A comprehensive list of types is infeasible due to page limit.) However, it is important to note that numbers did not work alone, and sometimes players triangulated multiple numbers to develop an explanation. For

instance, we discussed how P19 used both long-term statistics and his own rank to infer that his opponent was probably a smurf.

Codes for purposes: 1: self-evaluation; 2: inferring about others' skill; 3: inferring about others' mentality; 4, strategizing gameplay

Table 2. Representative types of numbers and purposes.

Types	Purposes	Description
Player ranks such as Gold and Diamond	1, 2, 4	Player rank was the primary if not the most important indicator of player skill (1, 2). Players respected and followed higher-ranked players (4).
Long-term stats on a champion such as KDA, win rate, and CS	1, 2, 4	These cumulative averages indicated how good a player was at this champion (1,2), and supported strategizing gameplay around teammates who picked familiar champions (4).
Recent match history (esp., the win/loss ratio)	3, 4	A loss streak in recent matches could cause anxiety and frustrations (3). To win, players could make plans to constrain and frustrate an opponent who was already frustrated (4).

Such multiplicity of meanings and purposes highlights the vast flexibility of interpreting numbers in LoL. Such interpretive flexibility of numbers is rooted in players' diverse sets of situated knowledge. For example, P5 and Yasuo players would have very different opinions about whether a win rate of 55% was good enough on Yasuo. P15 once disagreed with her teammates upon the interpretation of KDA.

Importantly, beneath these disagreements over how to interpret numbers was in fact the authority many LoL players granted to the numbers and quantification tools. Authority, according to Weber, is a form of power that is legitimate without either coercion or threat of violence [78]. Such numerical authority resided in many characteristics of quantification tools: the overwhelming amount of numbers that implied their comprehensiveness, the archival of complete historical data that expressed a sense of continuum, and the fast response time that communicated reliability. Numerical authority also rested in players' own practices, such as their sustained use and learning to use, and their discussions with others regarding how to use quantification.

Numerical authority guided players to develop categories such as the dichotomy between "good" and "bad," albeit in a distributed and informal fashion. Still, players' classification activities resonated with what Bowker and Star warned about the ramifications of institutionalized and formalized classification systems [5]. For example, the South Africa racial classification system sorted individuals into four major racial groups which intrinsically supported the ruling classes' identity and legitimacy, but Bowker and Star found individual cases that did not comply with the legal and technical-scientific delineations [5]. In our study, players agreed upon the purposes of various numbers, but were rarely unanimous on how to interpret them. Classification activities were constantly carried out at the individual level and met constant pushback as players rejected to be classified as "bad" players. Without institutional push and practical needs, it is possible that players' classification activities are in in a constant flux, manifesting a complex dance between interpretive flexibility and numerical authority.

6.2 Quantification and the Communicative Aspect of Trust

Resonating with many game scholars' observation of the blurring boundary between work and play [56,57,80], LoL players' participation also involved intense work in terms of the sheet amount of knowledge to learn about, necessary attention, energy, and techniques to guarantee their performance. Therefore, quantification did not simply enhance or challenge LoL's virtual teamwork. Rather, it had an intensifying and complicating effect by demanding cognitive engagement from all players who were already "working." Therefore, there were parallels between the use of quantification in LoL teams and collaborative traces in global software development.

Building upon prior discussions of the utility of collaborative traces in developing trust in virtual teams [55,74], in this paper, we found similar cases such as P12's example where LoL players developed better understandings of and trust in their teammates, and proceeded to strategize around competent teammates. However, these cases were oftentimes ideal scenarios where teammates perceived each other's numbers in an acceptable range and were willing to coordinate.

Discussing how trust can be developed or enhanced by quantification speaks to the notion of instrumental trust [8]. Instrumental trust rests upon instrumental rational efficiency of the system, or the instrumental value of quantification to players in our study. However, Brown sees trust as "inherently irrational and affective," because trust is a response to uncertainty, which is then linked to potential anxiety [8]. Therefore, the instrumental perspective is insufficient in understanding the relationship between quantification and trust. Players could easily develop trust or expectations in their teammates with superior numbers that had a convincing power. However, our findings about individuals' anxiety as well as team-level tensions and conflicts reflected the inherent irrationality and affection in the process in which players used quantification with ensuing trust or distrust. Therefore, our findings point to nuances and complexities of trust beyond the instrumental perspective.

Niklas Luhmann proposed the notion of communicative trust [51]. According to Luhmann, communicative trust has three qualities: the process of trust requires mutual commitment as two sides must be involved; the building up of trust depends on easily interpretable situations and possibility of communication; and trust can only be offered and accepted, not demanded [51]. Indeed, our findings resonate with this communicative aspect of trust. To cope with the trust issues in their teamwork, players frequently performed various communicative acts. They could draw upon their own numbers to legitimize a claim, to confront their teammates' decisions which they deemed unhelpful to team, or to negotiate strategies. Through communication, trust and distrust could be expressed, established, enhanced, or diminished.

The communicative aspect of trust was heightened in LoL teams in comparison to previously studied global software development teams, for several reasons. First, despite the many parallels between work and play, LoL's teamwork environment often lacks professional etiquette and courtesy that would be more typical in workplace [17]. By contrast, LoL is an online game where interpersonal aggression is a common theme [43,48,71]. Therefore, it is perhaps unsurprising that almost all of our participants reportedly spoke out in game, expressing concerns about trust. Second, LoL is a highly competitive team-based game, and players need to rely on their teammates to win [43]. Therefore, players often have scrupulous attention to their teammates' performance and status. Third, LoL players considered their numbers as part of their identity and endeavored to improve them [44], much like prior studies of how social media users made efforts

to improve their numerical representations [22,38]. Taking pride in their own numbers, players might defend against teammates' questions and doubts.

The perspective of communicative trust also invites reflections upon possible hidden disagreements and tensions when researching and implementing collective traces for trust. It is likely that people have diverse interpretations of capacity and performance, even in ideal scenarios where through predefined measurements collective traces are reported to enhance trust. Unrecognition of invisible disagreements and tensions could have a deteriorating effect in the long run. It is important to investigate what narratives or perspectives are preferred, and what are rendered invisible or marginalized.

6.3 Proper Use of Quantification

Our findings reported a variety of negative consequences and burdens as perceived by our participants. There were stress and anxiety as the individual level, and conflicts and tensions at the team level. These negative consequences echoed a few HCI studies of self-tracking that reported on emotional burdens [15,42]. When players ascribed much authority to numbers and believed in numbers' explanatory and prescriptive power, the power relation was produced and reproduced between people and technology. But in this power relation, it is quantification tools that discipline and punish people, instead of people consciously manage technology use.

In self-tracking the notion of self-knowledge was often traced back to Foucault to discuss how self-tracking technologies could help the production of self-knowledge [49,53]. However, Foucault stressed the importance of human agency in discovering self-knowledge, and examined how self-examination such as confession and reflective writing constituted technologies of the self [28]. That is, the discovery of self-knowledge is only enacted when people keep interrogating themselves about their relationships with any entities beyond the self, including the numbers. However, when quantification tools acquired numerical authority from players, it became epistemologically dangerous if players blindly bestowed trust in quantification tools. The numerical authority prescribed player actions towards caring about numbers, improving numbers, and judging others based on numbers.

It is against this backdrop that certain players became aware of the ramifications of quantification. They stressed proper use of quantification. By proper use we mean players individually developed normative judgments on how and when to use quantification tools. They did not presume knowledge obtained from quantification was the absolute truth. They perceived limitations of numbers and knew that they should use quantification in a proper way so as to avoid negative consequences such as frustration, anxiety, and aggression towards teammates. Therefore, proper use of quantification in our study has two orientations: one towards the inner self where players took care of their own mind and emotion, and one towards the social where they tried to sort out the proper relationships with other players. Both orientations were intertwined and together constituted proper use of quantification in players' terms.

The inward and outward orientations manifested themselves both cognitively and emotionally. Along the inward orientation, cognitive proper use suggested that players could reasonably and logically develop understanding of their own skill and performance. For example, a player would not make judgments about their skill based on bad KDA in one single match, but would perform detailed analysis to cultivate deeper understanding of themselves and the game, drawing from their situated knowledge. Emotional proper use suggested that players could effectively manage their emotions when watching their own numbers. They would easily cope with frustrations and anxiety. Along the outward orientation, cognitive proper use suggested that players could

reasonably and logically reason about another players' capacity. Emotional proper use suggested that players would not perform aggressive behaviors such as harassment towards their teammates and opponents.

Importantly, what constituted proper use of quantification was highly individualistic. Players might have vastly different ideas of what constituted their own proper use. For example, we have several players who reportedly felt comfortable checking every single opponent and teammate during a match. But we also have P21 and P22 who refrained from doing so to take care of their own mind.

7 IMPLICATIONS FOR DESIGN

The findings in this paper seek to present a holistic narrative of quantification use in a site, and is intended to propose "new ways of imagining the relationship between people and technology" [19]. Drawing from previous literature and our findings, we discuss several design implications. First, while players granted numerical authority to quantification tools, mutual understanding and shared ways of interpretation are still missing. This is in sharp contrast to the maturized player statistical analysis and measurement systems in sports, such as sabermetrics in baseball and APBRmetrics in basketball [16,70]. Contested interpretations and understandings resulted in diverse play preferences that players disagreed a lot upon. Therefore, for eSports games to move forward, it is perhaps helpful if authorities such as game developers could carry out efforts in standardizing and classifying player metrics. However, from a critical point of view, they should also be aware of the potential ramifications of establishing a centralized, formalized classification system (see [5,63]). For example, the diversity of player experience might suffer as players are further motivated to choose only top-ranked play styles such as champion picks, team composition, and in-game strategies.

Second, in terms of the amount of numbers for acquiring self-knowledge, more is not better. Statistics, measurements, analyses on the third-party websites were already extensive and complicated, but they did not fulfil players' needs in understanding themselves or their teammates. Players had the burden of combing through all the statistics to come up with their own ways of explanation, often intuitively. One possible solution is to improve the visualization of these quantification tools, like many collective trace tools already explored [29,74]. Currently many quantification tools merely present numerous tables showing all the player data (e.g., Figure 1).

Third, the wide range of situated knowledge necessary for making sense of numbers demands players, especially beginners, to learn how to interpret numbers and derive insights. Our findings showed that players utilized online forums to seek help. Currently most quantification tools only provide raw data in forms of table. They could bridge this knowledge gap by employing advanced data analytic techniques to provide certain insights into how to improve gameplay.

Fourth, players needed to switch windows between their game client and third-party quantification tools to get informed. This is consistent with the contemporary industry practices of commercial game companies that rely upon enthusiastic players to voluntarily develop third-party tools and in-game add-on items [47]. However, it creates additional labor for players. Future game design could consider presenting more statistics for players.

Lastly, our discussion of communicative trust suggested that it is important to attend to individual teammates' interpretations and potential disagreements. Design of collaborative traces could consider ways of encouraging direct communication of trust and distrust, and resolving

potential tensions at an early stage. For example, a communication channel could be opened whether interpretations of traces could be exchanged and explained.

8 LIMITATION AND FUTURE WORK

With a primary focus on the role of quantification in virtual teams in League of Legends, this study left many underexplored areas that warrant future analysis. One such area is the privacy concerns of LoL players as the owner of League of Legends publicizes their personal data. In the main body of this paper, we analyzed how players held a pragmatic attitude towards such publicity, but such acceptance was also contested, as a few players did express certain privacy concerns. Future work can be done towards a more systematic analysis. Another underexplored area is the aesthetics of quantification, manifested in LoL players' consumption of the charts, graphs, and tables presented by quantification tools. Espeland and Stevens suggested two universal aesthetic ideals for numerical pictures which are clarify and parsimony [26]. We observed that players were aware of the great variety of available tools, and talked about whether the views presented by particular tools were "messy" or aesthetically pleasing. Future work can compare different tools along this aesthetic dimension.

9 CONCLUSION

In this paper, we reported an ethnographic account of quantification in League of Legends. We analyzed how quantification was adopted as an integral part of the highly competitive gaming culture. We observed the complicated relationship between players and numbers comprised of interpretation and negotiation. By analyzing numbers as deeds, we started to see how numbers gained authority and exerted influence over players. This case of quantification use in an online game community also inspired us to reflect on broader issues such as what constitutes self-knowledge obtained through quantification, the interplay between quantification and surveillance, and the role of quantification in virtual teams. We thus caution against an optimistic tone of narrating quantification as a way of empowering, and stress a reflection on the proper use of quantification against the backdrop of the increasing prevalence of personal informatics systems.

ACKNOWLEDGMENTS

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