When a Pandemic Enters the Game: The Initial and Prolonged Impact of the COVID-19 Pandemic on Live-Stream Broadcasters on Twitch

Alexei Scerbakov
Graz University of Technology
alexei.scerbakov@student.tugraz.at

Johanna Pirker
Graz University of Technology
johanna.pirker@tugraz.at

Frank Kappe
Graz University of Technology
fkappe@tugraz.at

Abstract

The global COVID-19 pandemic has accelerated the popularity of video games and online gaming platforms. However, little research is devoted to understanding how the pandemic has affected gamers, especially live-stream broadcasters. Therefore, our study aimed to evaluate the impact of the COVID-19 pandemic on the established streamers on Twitch. By using a longitudinal time-series design and focusing on a large sample (N = 23,019) of broadcasters, we could determine the initial as well as the prolonged effects of the pandemic on their streaming behaviour. Our results suggest that the pandemic was a "game changer" for the target group, especially in regards to their choice of game setting and the focus on non-gaming content. Furthermore, by relating the data obtained from our target group of established streamers to the general platform data, the pandemic related platform dynamics are discussed. [1]

1. Introduction

Pandemics are defined as large-scale outbreaks of infectious disease with substantial health, social, and economic implications [1]. The World Health Organization [2] declared the outbreak of the novel coronavirus disease 2019 (COVID-19) a global pandemic on March 11, 2020 [3]. In order to minimize the spread of the virus, many countries introduced restriction/lockdown measures including stay-at-home orders, quarantines, mobility restrictions and physical (or social) distancing mandates [4] [5]. The implementation of these measures has led to closure of social facilities as well as cultural and entertainment venues [6].

[7] argues, that the distressing information about the pandemic in the media as well as governmental lockdown measures have most likely had a profound psychosocial effect on the general population. For many people, the COVID-19 pandemic imposed a psychological burden inducing feelings of social isolation, loneliness, depression, stress and anxiety [8] [9]. Moreover, the pandemic generated an emotional climate of uncertainty, eliciting anxiety, fear and sadness [10] [11] [12], while at the same time also evoking feelings of resentment and anger [6].

To alleviate these negative emotions and to escape the boredom, loneliness, anxiety, and stress many people turn to video games and online gaming platforms [13] [14]. Technology can be helpful in improving the negative outcomes resulting from social isolation. Thus, gaming can be an adaptive coping mechanism [15] and a useful tool for diminishing some of the negative impacts of the pandemic [16]. Moreover, online games can provide a means of socializing with others and create a sense of community and well-being [17].

The perception of video game players as anti-social "loners" is no longer accurate due to high engagement with others during gameplay [18] [19] [20]. Thus, gaming provides a social experience for players, which could especially be beneficial during the pandemic lockdown measures. Notably, social media initiatives such as #PlayApartTogether encourage players to continue social engagement in video games and promote gaming for socializing and stress reduction during the COVID-19 crisis [21].

Nowadays gamers are not just playing the game, but are broadcasting their gaming sessions live on certain platforms. To better understand how the pandemic has affected (and is affecting) the habits of video game players, we choose to focus our research on one specific platform, Twitch, which is currently the world's leading live streaming platform that focuses on video game content. Moreover, broadcasters are able to benefit financially from increased audience sizes (viewer numbers) through "subscriptions" and/or advertisement revenue. This financial motivation can be a big incentive for less successful streamers to follow the path of their more successful counterparts [22]. Thus, broadcasters (streamers, often game-streamers) with large audience

sizes can be highly influential, not only on their viewers, but on the platform as a whole, because e.g. their "*choice of game to play affects the gameplay choices of other streamers*" [22]. To take that into account, we centered our study on established streamers, a sample of Twitch broadcasters with the highest viewer numbers in December 2019.

The focus on established streamers offers several advantages. First, it offers the possibility to examined Twitch as a platform in more detail, as the contribution of the target group of streamers (established streamers) to the overall pandemic-related changes on the platform can be evaluated. Second, potential changes in content pre- and during the pandemic may indicate that gamers use content as a coping a strategy (as research evidence suggests that positive and negative effects of gaming on well-being depend primarily on their content) [23].

The following research questions were of particular interest:

- RQ1: Did the COVID-19 pandemic affect the engagement in streaming (stream count, average stream length) of the target group of content creators (established streamers)?

- RQ2: Did the COVID-19 pandemic affect the engagement in viewing (viewer count) of the content provided by the target group of content creators (established streamers)?

- RQ3: Did the COVID-19 pandemic affect the content (categories, genres) broadcasted by the target group of content creators (established streamers)?

The impact of COVID-19 on streaming (RQ1 + RQ3) and viewing habits (RQ2) was evaluated by using a pre-post-follow-up design. Thus, we were able to assess the initial effects as well as follow-up effects of the pandemic. Furthermore, weekday/weekend differences in streaming (RQ1) and viewing (RQ2) behaviour were examined.

2. Twitch

Twitch is currently the biggest live (video game) streaming platform, with almost 3 million viewers and over 106,000 broadcasts active on average at any time [24]. Live streaming in general differs from other user-generated content platforms, such as YouTube, mainly due to the possibility of an active, simultaneous broadcast participation of both, content creators (broadcasters or streamers) and the live streaming audience (viewers) [25]. The chat feature allows the viewers to actively participate in the

broadcast by interacting with the streamer and/or other viewers [26].

COVID-19 had a substantial impact on Twitch as a platform in general. Data from [27] and [28] show that the number of streamers as well as the number of viewers experienced a tremendous increase in the course of the pandemic. More precisely, all metrics, namely total hours streamed as well as total hours watched (Fig. 1), total unique channels and average concurrent viewers (Fig. 2) experienced an enormous boost following the outbreak of the COVID-19 pandemic in the first quarter of 2020 and kept growing until today. In all of the mentioned metrics the increase from the first to the second quarter 2020 was the greatest observed, in the following quarters the increase continued in a slower pace. This suggests, that the initial effects of the pandemic were far faster paced (more profound increase) than the prolonged ones (less profound increase). Viewers per stream on the other hand declined during the pandemic until 3rd quarter of 2020 as can be seen in Fig. 3, meaning that the increase in unique channels (streamers) outpaced the increase in viewer numbers.
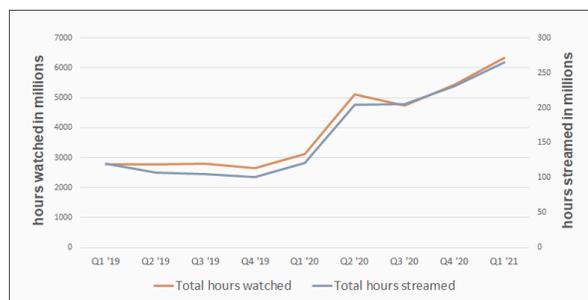
Note: Data derived from Streamlabs Report 2021

Figure 1. Quarterly hours streamed and watched on Twitch
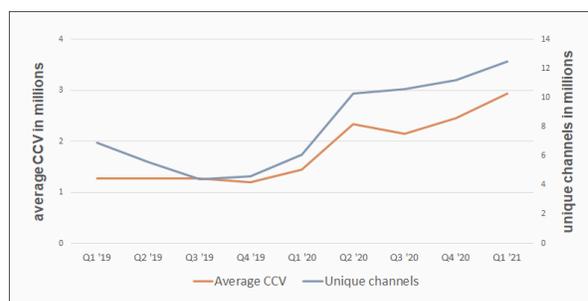
Note: Data derived from Streamlabs Report 2021

Figure 2. Quarterly unique channels and average concurrent viewers on Twitch

Research has demonstrated that the engagement in streaming and viewing on Twitch is higher on weekends,
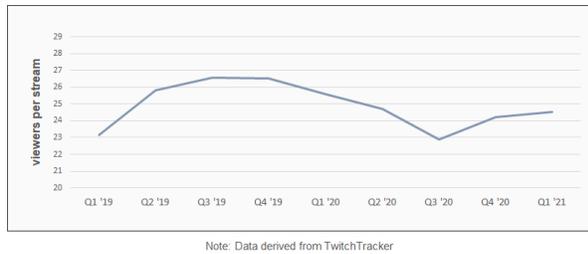
Note: Data derived from TwitchTracker

Figure 3. Quarterly viewers per stream on Twitch

compared to weekdays [29] [30]. Current platform data show that the weekdays/weekends difference on the platform in the first six months of 2021 is still present, with 5% more viewer and 14% more streamers active on Twitch on the weekends

3. Related Work

With the rapid growth of video game live-streaming services, its users, as well as their motivations and behaviours became a popular topic of research. Previous studies have explored the relationship between gaming motives and genre preferences (Quelle; Quelle), the role of community in live streaming (Quelle), the motivations of players to engage in gaming (Quelle;Quelle;Quelle) and the motives of viewers to engage in watching others play video games (Quelle;Quelle;Quelle;Quelle). Findings of studies evaluating the motivations for streaming and viewing engagement on Twitch indicate, that social interaction and social integration are very strong motivators for streaming and viewing video game content (Quellen).

We argue, that the relevance of these socially oriented motives for the engagement in video game live-streaming has most likely been elevated due to the COVID-19 pandemic and its containment policies, contributing to the attraction of Twitch and accelerating its growth. Consequently many newcomers joined the platform, confronting its established users with new challenges. While Perks (Quelle) has addressed the challenges of community managers within online communities, such as YouTube and Twitch in times of the pandemic, little is known about the behavioral reactions of the established streamers to the pandemic and the pandemic-related social alterations within their communities. Wollborn et al. , showed that established streamers on Twitch experienced an increase in viewership during the initial stages of the pandemic, which indicates that their communities are growing. However, with increasing viewer numbers meaningful personal social interactions are rather unlikely to occur. (Quelle;Quelle).

Therefore, (established) viewers may get frustrated and less engaged, which is unfavorable for the channel/streamer due to the fact, that streamers themselves are interested in the social and psychological benefits of being part of a meaningful community. Hamilton et al (Quelle) report that many streamers, even those with larger viewer numbers and regardless of their Twitch Partner status, see their regular viewers as their friends and they enjoy to sociably interact with them while streaming.

Therefore our study aims to understand how the streamers on Twitch will react to these challenges in terms of their streaming behaviour (engagement in streaming). Considering that a sense of community has been shown to be an important contributor to the engagement in live-streaming on Twitch (Hamilton et al., 2014), we propose that following scenarios are possible: broadcasters can produce more content (SC) and/or longer broadcast sessions (ASL) to offer their communities more time-frames to watch their streams and provide themselves more time to engage with their communities. Alteration of content by e.g. increasing the stream lengths of non-gaming categories would be another option to promote social interactions. Leith (Quelle) states, that the non-gaming category Just Chatting generally refers to broadcasts in which the streamer primarily focuses on communication with either other streamers or their viewers. Therefore non-gaming categories could enable streamers to have deeper conversations surrounding e.g. important social topics with their audiences.

Previous research used the time invested on content creation as in indicator for the engagement in streaming on Twitch (Quelle), and time invested on content consumption as in indicator for the engagement in viewing (Quelle;Quelle). Accordingly, we incorporated SC and ASL as an indicator for the engagement in streaming, but - since our reasearch is focused on broadcasters - used AVN as an indicator for the engagement in viewing. Former studies adressing the broadcasters perspective relied primarily on subjective survey methods to assess their engagement. Our research offers an objective and more reliable approach, which was previously used by Wollborn et al. (Quelle) to evaluate pandemic related outcomes on Twitch. However, the authors only determined the initial effects of the pandemic and did not evaluate the prolonged impact on established streamers. Our study aimes to address this gap by investigating pandemic related responses of established Twitch´ streamers and their viewers over a long observational period and with a large sample of broadcasters.

Table 1. Broadcaster-Specific Data

broadcaster ID	broadcast/stream					
	qualitative			quantitative		
	title	language	category	start time (min)	end time (min)	viewer count (number of viewers)

4. Data and Methodology

To answer our research questions, we selected a data driven approach by collecting Twitch data via a serverless infrastructure. Data was collected since the start of the last year (2020) up until April 1st, 2021.

4.1. Data and Pre-Processing

We used present technical possibilities offered by Twitch to access platform data. Twitch offers a manifold application programming interface (API) as well as webhook based data collection possibilities. Various platform specific data can be accessed. We gathered the required data by subscribing to web-hooks for the top 50,000 Twitch streamers (based on their VC for December 2019), this list was exported from the service Sullygnome [2].

A serverless infrastructure was used to keep hardware setup and maintenance effort as low as possible, and guarantee minimal downtime. An AWS lambda function was deployed and handled incoming webhooks by persisting the incoming stream specific Twitch metadata to a MongoDB database. The database was hosted on a cloud service provided by MongoDB itself called Atlas, making the whole data collecting and persisting process handled in the cloud (serverless). With this approach we were able to build a database, consisting of 19,145,474 streams.

We used a within-subject design to evaluate the impact of the pandemic on the established streamers. Thus, we focused our research on streamers who were (regularly) active on Twitch before the outbreak of the pandemic (baseline) and continued streaming in the course of the pandemic. Therefore, we filtered the full set of streamers to a subset only containing broadcasters who had at least one active stream every month in 2020 (minimum of twelve streams in 2020). This resulted in a final set of 23,019 broadcasters.

Tab. 1 shows broadcaster-specific data used in the present study. Tab. 2 describes the calculation behind the metrics referenced in this paper.

To evaluate the impact of the pandemic restrictions on the dependent variables (SC, ASL, AVN, PCSC,

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[3]Twitch webhooks handle restarted streams by providing an ID when the webhook is triggered. Consequently, if a stream was restarted it was only counted once in our database.

Table 2. Metrics

metric	description
Stream count (SC)	SC is the total number of streams[3] SC was calculated per day (24h)
Viewer count (VC)	VC is the total number of viewers VC was calculated per day (24h)
Stream Length (SL)	SL is the difference between end time and start time of a stream
Average stream length (ASL)	ASL is the ratio of SL to SC
Average viewer numbers (AVN)	AVN is the ratio of VC to SC
Percent change in streamed content (PCSC)	PCSC = (SL$_{follow-up1}$*100/SL$_{baseline}$) PCSC is measured in % and was calculated per category
Percent change in viewer count (PCVC)	PCVC = (VC$_{follow-up1}$*100/VC$_{baseline}$) PCVC is measured in % and was calculated per category

PCVC) we segmented the data in four time periods (Fig. 4), based on the public announcement of the pandemic by the WHO on March 11, 2020 [3], revealing four conditions for further statistical analysis:

- period 1: baseline (January 1st – March 11th, 2020)
- period 2: initial effects (March 12th – March 30th, 2020)
- period 3a: follow-up$_1$ effects (January 1st – March 11th, 2021)
- period 3b: follow-up$_2$ effects (March 12th – April 1st, 2021)
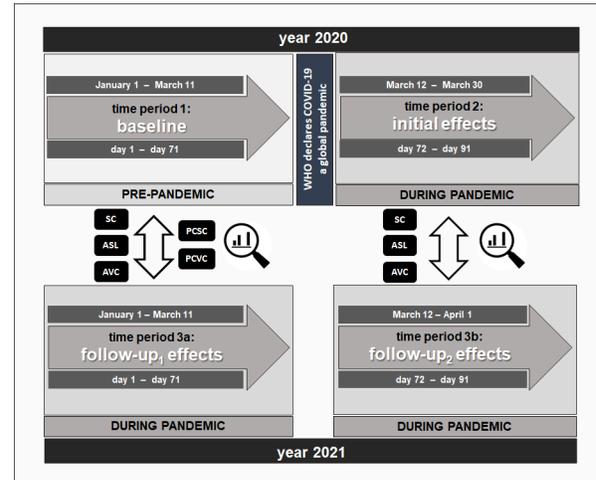
Figure 4. Study design

The baseline condition, represents the period of time before COVID-19 was declared a global pandemic by the WHO, while the other three conditions refer to time frames after the announcement of the pandemic, revealing its effects. We are well aware, that splitting period 3 in two separate subconditions (3a and 3b) is artificial, but necessary in order to statistically compare the exact same periods of time in both years and therefore to avoid or at least to reduce bias (from e.g., seasonal fluctuations in streaming behavior).

4.2. Statistical Analysis

The study objectives were analysed using the computer software Excel (Microsoft, Redmond, WA) and SPSS 27 (IBM SPSS Statistics for Windows, USA). Excel was used for the calculation of the relative data, means and standard deviations. SPSS was used to analyze the data distribution as well as the significance of differences. Paired-sample t-tests or alternatively Wilcoxon tests if the assumption of normality was violated (Kolmogorov Smirnov test of normality, $p < 0.05$) were used to assess differences between period 1 (baseline) and period 3a (follow-up$_1$ effects) as well as between period 2 (initial effects) and period 3b (follow-up$_2$ effects). The differences between weekdays and weekends were assessed by using unpaired t-tests or Mann-Whitney-U-tests for data which failed to meet parametric assumptions. A p-value below 0.05 was considered as statistically significant. We used different methods to visualize our results. Line charts were used for understanding the course of the metrics SC, ASL and AVN in year-over-year comparison. The x-axis is representing the days starting from the 1st of January (for both years), with the timeframe highlighted when the pandemic started (starting day 71). The y-axis was either represented by absolute numbers or by percentages where a natural growth aside from COVID-19 could be expected (viewer numbers). Bar charts were used to highlight changes between time periods as well as between weekdays and weekends in all relevant variables. Data are presented as means and standard deviations or percent. All p-values are based on 2-tailed tests of significance.

5. Results

5.1. Stream Count

The daily number of steams (stream count; SC) over the time period of 90 days (January – April) in the course of two years (2020 and 2021) is demonstrated in Fig. 5. It can be observed, that there was a prominent increase in SC after the pandemic was publicly announced by the WHO on March 11, 2020 (day 71). In 2021 no noteworthy differences in SC to pre-pandemic levels are evident.

There was a significant difference ($p < 0.001$) between the initial and the follow-up$_2$ effects on stream count, indicating that the number of streams was significantly higher after the announcement of the pandemic in 2020 than in the same time period in 2021. However, no statistical significant difference ($p = 0.194$) was evident between period 1 (baseline) and period 3a (follow-up$_1$ effects), which suggests that after the initial
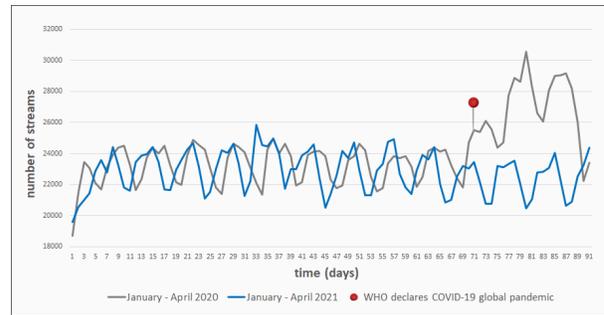

Figure 5. Daily stream count

"pandemic boost", the number of broadcasts reached baseline levels in 2021 (Fig. 5).

Significant differences between weekdays and weekends could be observed in period 1 (baseline) ($p < 0.001$), as well as period 3a (follow-up$_1$ effects) ($p < 0.001$) and 3b (follow-up$_2$ effects) ($p = 0.003$), but not for period 2 (initial effects) ($p = 0.667$). The number of broadcasts was on average higher on weekdays compared to weekends in all examined conditions/time periods, indicating that streamers, who regularly create content, prefer to stream during the weekdays (Fig. 6). However, the differences in stream counts between weekdays and weekends were fairly small – on average 1094.39 streams (4.63%) in favor of the weekdays.
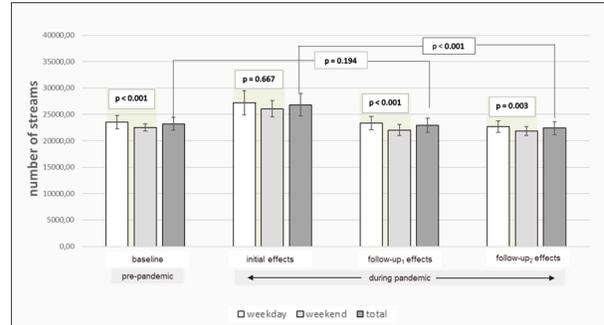

Figure 6. Average Stream Count by Time Period

5.2. Average Stream Length

The average stream length (ASL) over the time period of 90 days (January – April) in the course of two years (2020 and 2021) is demonstrated in Fig. 7. It can be observed, that ASL values were significantly lower and with more fluctuations in 2021 compared to 2020.

Paired samples t-test results revealed that there was a significant difference ($p < 0.001$) between period 1 (baseline) and period 3a (follow-up$_1$ effects) in ASL, indicating that streams were on average significantly longer before the announcement of the
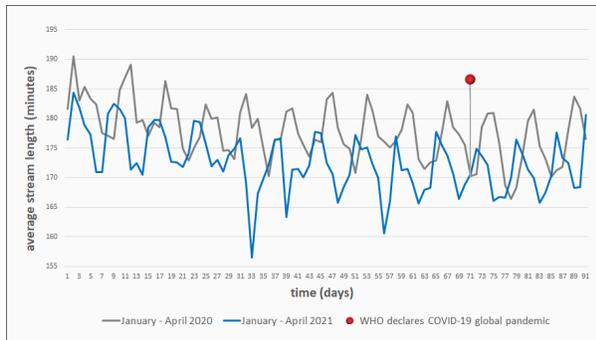
Figure 7. Daily stream length

pandemic in 2020 than in the same time period in 2021. Furthermore, there was a significant difference (p = 0.025) between the initial and the follow-up$_2$ effects on ASL, revealing that under pandemic restrictions streams were on average significantly shorter in period 3b (follow-up$_2$ effects) than in period 2 (initial effects) (Fig. 8). Overall, the average length of broadcasts on Twitch was shorter in all conditions/time periods after the pandemic announcement than before (baseline), indicating that streamers produced on average 5.5 minutes less content per broadcast during the pandemic in comparison to baseline (time-period before the pandemic announcement). Regarding the differences between weekdays and weekends, we could identify significant differences within all time periods/conditions (p $\leq$ 0.001). Streams were on average longer on weekends compared to weekdays in all examined conditions/time periods (Fig. 8). However, the differences in ASL between weekdays and weekends were fairly small – on average 6.56 minutes in favor of the weekends.
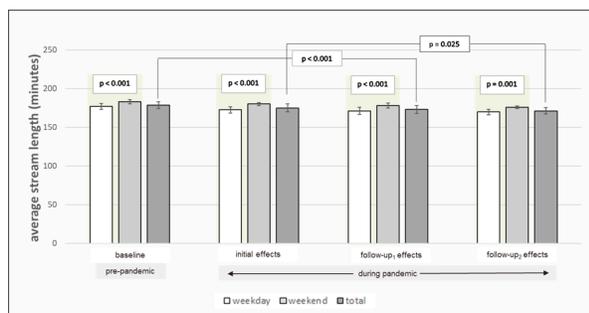

Figure 8. Average Stream Length by Time Period

5.3. Average Viewer Numbers

Overall, the average viewer numbers of broadcasts on Twitch were higher in 2021 than in 2020, indicating that there were no noteworthy initial effects of the

pandemic on AVN, but significant follow-up effects, with an average increase of 205.41 (+70.93 %) viewers in 2021 in comparison to baseline. This is also evident in Fig. 9, which shows normalized (relative to day 1 of each year) percentage changes in viewer numbers.
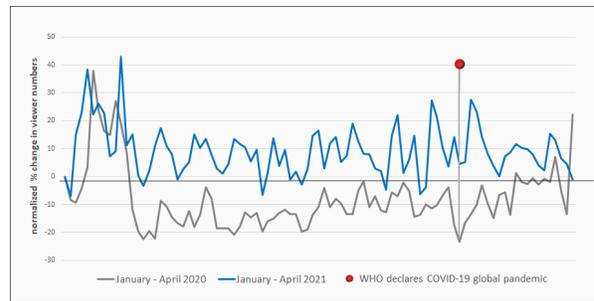

Figure 9. Daily viewer percentage change

In comparison to baseline, average viewer numbers per stream (AVN) were significantly (p < 0.001) higher during the time period 3a (follow-up effects$_1$), indicating that on average broadcasts on Twitch were watched by significantly fewer viewers before the announcement of the pandemic in 2020 than in the same time period in 2021. Furthermore, there was a significant difference (p < 0.001) between the initial and the follow-up$_2$ effects in AVN, indicating that during the pandemic significantly more viewers consumed content in period 3b (follow-up$_2$ effects) than in period 2 (initial effects).

Differences between weekdays and weekends were more prominent in 2020 and less prominent in 2021. The most prominent difference was observed in the time period after the pandemic announcement in 2020 (initial effects) with an average of 33.25 more viewers/stream on weekends. The least prominent difference was identified in the follow-up$_2$ phase in 2021 with an average of 2.72 more viewers/stream on weekends. However, significant difference between weekdays and weekends in AVN could only be determined at baseline (time period before the pandemic announcement) (p = 0.002), while no significant differences were present within all time periods during the pandemic (p > 0.05) (Fig. 10).

5.4. Streamed Content

To evaluate the impact of the pandemic on streamed content on Twitch, we identified the 100 most broadcasted categories before the pandemic was publicly announced by the WHO (baseline), based on SL. Then we retrieved SL of these 100 categories for the time period 3a, which was after the announcement of the pandemic (follow-up$_1$ effects). By calculating the baseline/follow-up$_1$ ratios in SL for each category,
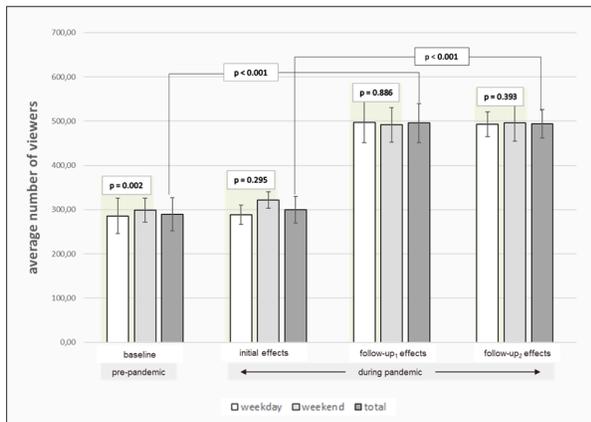
Figure 10. Average viewer number by time period

we could evaluate the changes in SL (PCSC). The same procedure was carried out for the viewer count (PCVC).

We could determine that 90 of 100 categories had a positive change in VC, while only 19 categories had a positive change in SL. Therefore, we looked at these 19 categories in more detail. By classifying the categories in gaming and non-gaming content, we could determine that non-gaming content gained on average 12.35% in SL, which indicates that established broadcasters on Twitch are more interested in content outside of the traditional gaming format during the pandemic than before (Fig. 11). Given the fact that neither SC nor ASL increased during the pandemic in 2021 (in comparison to pre-pandemic announcement), makes this observation even more remarkable.
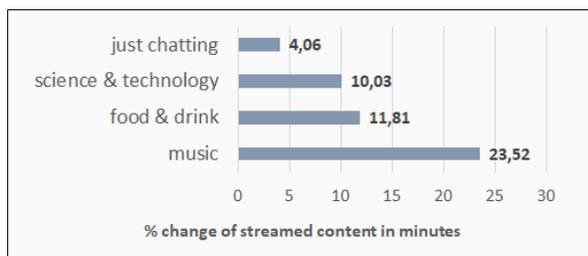

Figure 11. Non-Gaming Categories

Of course, gaming content remains still relevant during the pandemic with an average gain of 39.08% in SL. However, a basic and fundamental question to understand the impact of the pandemic on broadcasters is to evaluate the change in content being broadcasted by them. By collecting game data from the 'GiantBomb' API [4], an open, online database for video games and by using Apperley's classification [31], we classified the content in game genres. Thereafter, we looked at

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[4]https://www.giantbomb.com/api/

categories with the most significant gain in SL within each genre in more detail.

The *action* genre included the most categories (6/15) and had the most prominent average gain of 52.67% in SL, followed by *simulation* (2/15 categories; +44.62% in SL), *role-playing* (5/15 categories; +33.63% in SL), and *other* (2/15 categories; +6.36% in SL). Within the *action* genre we could observe, that three out of six categories with the most significant increase in SL (Rust, Call of Duty: Modern Warfare, DayZ) were shooter video games with either a *survival setting* (Rust, DayZ) or a *war setting* (Call of Duty: Modern Warfare). Given the fact, that COVID-19 can be considered as a huge worldwide stressor triggering fears and uncertainties [32], our findings suggests that a relation between real-life-stressors and settings chosen in video games could be present.

Within the *role-playing* genre we could observe, that three out of five categories with the most significant increase in SL (Stardew Valley, Lost Ark, Path of Exile) were either MMORPGs (Lost Ark, Path of Exile) or had a nostalgic setting (Stardew Valley) [33]. While MMORPGs are purposefully designed to encourage interactions among users, which are highly restricted in-real-life due to the pandemic, choosing nostalgic settings could provide nostalgic reverie, which in turn could be positively connected to resiliency [34] [35] and therefore be beneficial, especially during the pandemic. The increased interest in nostalgic settings during the pandemic is also supported by the gain (+6.36%) in SL of the two categories (Retro and Super Mario World) present in the genre "other".

The remaining two categories (*Slots* and *Chess*) could be classified as *simulation* games. The *simulation* genre includes video games that simulate real-life-activities, like - in our case - gambling (*Slots*) and strategy board gaming (*Chess*). While Slots gained 8.7% in SL during the pandemic, the change in SL for *Chess* was even more remarkable: *Chess* gained a total of 80.55% in SL during the COVID-19 pandemic and was overall, the category with the second highest gain in SL (after Rust).

6. Discussion

With this study, we aimed to evaluate the impact of the COVID-19 pandemic on live-stream broadcasters on Twitch. By using a longitudinal time-series design and focusing on a large sample (N = 23,019) of broadcasters based on their (pre-pandemic) viewer numbers (established streamers), we could determine the initial as well as the prolonged effects of the pandemic on their streaming behaviour. Our variables
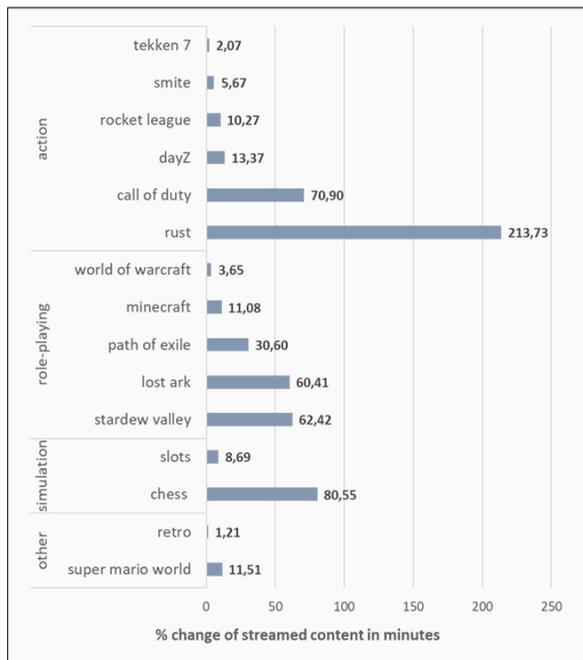
Figure 12. Gaming categories

of interest were *stream count* (SC), *average stream length* (ASL) and *type of streamed content* (based on PCSC), which in our opinion, best represents streaming behavior. Furthermore, we included the variable *average viewer numbers* (AVN) and *type of viewed content* (based on PCVC) in our analysis to examine the engagement in viewing pre- and during the pandemic.

6.1. Engagement in Streaming

After the pandemic announcement by the WHO there was a profound increase in SC (+15.5% compared to baseline), indicating that the initial reaction of the established streamers to the pandemic was to produce a higher amount of content. Furthermore, the differences between weekdays and weekends in SC, which were present pre-pandemic ($p < 0.001$), were insignificant ($p = 0.667$) following the pandemic announcement. However, SC returned to baseline values in 2021, indicating that the initial change in behavior following the pandemic announcement, did not last long-term. More precisely, after the initial "boost" in the amount of content broadcasted by the target group in the first weeks following the pandemic announcement, the pre-pandemic habits were resumed and maintained in the following year. The same could be observed for the weekdays/weekends differences in SC. Equal to baseline (pre-pandemic), the differences were significant in the follow-up$_1$ and follow-up$_2$ time-period

($p < 0.001$; $p = 0.003$), with significantly higher number of streams broadcasted on weekdays compared to weekends.

ASL decreased during the pandemic and remained below baseline levels in all time periods/conditions during the pandemic, indicating that the content, broadcasted by the established streamers in the course of the pandemic was shorter in length. On average, streamers broadcasted 5.5 minutes less content per broadcast during the pandemic in comparison to baseline. The differences in ASL between 2020 and 2021 were significant ($p < 0.001$; $p = 0.025$). Contrary to SC, this behavioral change seems to be persistent. However, the differences between weekdays and weekends, which were observed pre-pandemic ($p < 0.001$), did not change in the course of the pandemic. The content, broadcasted by the established streamers was significantly shorter on weekdays compared to weekends pre-pandemic as well as during the pandemic ($p \leq 0.001$).

In comparison to the general platform data [36], which show a profound increase in broadcasted content (hours streamed) on Twitch during the pandemic (Fig. 1), our findings indicate that the established streamers contributed to the overall platform growth only to a small extent, merely due to the increase in SC in time-period 2 (initial effects). What contributed the most, were most likely new broadcasters who joined the platform during the pandemic. This assumption is further supported by the overall increase in unique channels (Fig. 2). Contrary to general platform data, where 14 % more streamers were active on weekends, the established streamers broadcasted more content on weekdays. However, their broadcasts were significantly longer on weekends.

6.2. Engagement in Viewing

Significantly more (+70,93%) viewers were watching content broadcasted by the established streamers in 2021 compared to the previous year ($p < 0.001$). Moreover, the differences between weekdays and weekends, which were observed pre-pandemic ($p = 0.002$), were insignificant during the COVID-19 crisis ($p = 0.295$; $p = 0.886$; $p = 0.393$), indicating that the pandemic and its measures could have influenced the engagement in viewing during the pandemic.

General platform data show that the overall viewer numbers on Twitch experienced a profound increase during the pandemic (Fig. 2). However, the average viewer number per stream declined, indicating that more content was broadcasted on the platform. As our target group gained significantly more viewers (+71%) during

the pandemic, it is evident that the established streamers, unlike new broadcasters, benefited strongly from the overall viewer increase on the platform.

6.3. Type of Streamed Content

One of the most interesting observations was the gain in SL (from baseline to follow-up$_1$ time-period) of the non-gaming content, particularly in the categories *Just Chatting* (+4.06%), *Science & Technology* (+10.03%), *Food & Drink* (+11.81%) and *Music* (+23.52%). What makes this observation remarkable is the fact, that only 19 out of 100 categories had positive baseline/follow-up$_1$ ratios, indicating that these categories indeed may reflect a pandemic-related behavioral change. Of course, there was an enormous increase in new broadcasters on Twitch, as entertainment, educational and cultural activities were forced to move online in 2020 due to the pandemic. According to the Streamlabs Report, the number of unique channels on Twitch has doubled (6.1 million vs. 12.5 million) in Q1 2021 compared to Q1 2020 [36]. Thus, an increase of non-gaming content on Twitch in the course of the pandemic seems obvious. However, what makes our findings extraordinary, is the focus on the established streamers, who were present and established (following their large viewer numbers) on the platform before the pandemic occurred. Thus, the target group of established streamers was evidently changing their behaviour in the course of the pandemic by focusing more (in terms of SL) on the non-gaming content than pre-pandemic. Taking into account, that the ASL decreased in the course of the pandemic and the SC returned to its pre-pandemic levels in 2021, the increased SL of non-gaming content could indicate, that COVID-19 was indeed a "game changer" [37] for the established broadcasters, in the means of spending more time with their (real-life) activities online (*Music*, *Science & Technology*, *Food & Drink*) or coping with the pandemic measures in a socially-distanced world by increased engagement in *Just Chatting*.

Of course, gaming content remains still relevant during the pandemic. However, the pandemic has been a "game changer" for the gaming content as well. Especially the choice of game settings (or themes) seems to have been affected by the pandemic. In the action genre, the shooter game *Rust*, which has a *survival setting*, had the most prominent gain in SL (+213.73%) during the pandemic. In the role-playing genre, *Stardew Valley*, which had a *nostalgic setting*, had a leading role in regards to SL (+62.42%) (see [33] for further information how the rural idyll of farming computer games is connected with nostalgia). The

nostalgic setting was also present in the genre "other", which consisted of *Super Mario World*, a game with a "retro" style, and the category *Retro*. As mentioned in [38] the *"nostalgia that Mario games produce, rich down to the iconic theme tune and in-game sounds, colours, shapes, all come at the price of being tethered to the past"*. The same applies to other retro games [35] [39]. In the simulation genre, *Chess*, simulating a real-life activity online (*real-life activity setting*), was a definite winner in terms of gain in SL (+80.55%).

Research evidence suggests, that games can be used as a coping mechanism and that playing video games during the COVID-19 pandemic can indeed have a positive impact on players well-being by providing cognitive stimulation and opportunities to socialize as well as a variety of benefits related to mental health, including reduction in anxiety and stress [17] [37] [40] [14]. Several cognitive benefits of gaming are described in [20], one of which is developing problem-solving skills [41]. By choosing a *survival setting* in an action game and solving in-game (survival) problems by exploring a wider range of possible solutions can promote problem-solving skills in the reflective sense, like *"taking time to gather information, evaluate various options, formulate a plan, and consider changing strategies and/or goals before proceeding further"* [20], which may be especially beneficial in the emotional climate of uncertainty due to the pandemic.

An other benefit of gaming is their positive impact on well-being. Choosing a *nostalgic setting* in video games or playing retro games may be connected to nostalgia. Nostalgia is predominantly a positive, social, and past-oriented emotion [42], that is also positively associated with well-being [43]. Nostalgia is mostly triggered when social support is required [44], countering the negative impact of loneliness and/or social exclusion [45]. As the COVID-19 pandemic imposed a psychological burden on many people, feelings of social isolation, loneliness, and anxiety increased [8] [9]. [35] suggests that *"people who are currently in need of social support and relatedness may seek out a nostalgic gaming experience to feel socially connected"*. This may explain the popularity of retro games during the COVID-19 crisis as well as the choice of *nostalgic settings*.

The popularity of the *Chess* category on Twitch during the pandemic could have resulted from the streaming collaboration between Grand Master Hikaru Nakamura, a five-time US chess champion and Felix Lengyel ("xQc"), one of the top broadcasters on Twitch, in April 2020, attracting millions of viewers. Nakamura continued to collaborate with other well-known streamers and the popularity of the *Chess*

category on Twitch was quickly growing. However, while such collaborations may broaden the appeal of a category, we argue that a category can only remain relevant or expand its popularity, if there is an underlying interest in the category itself. As the COVID-19 pandemic and its prevention measures have drastically reduced social connection and cognitive stimulation [46], the increased engagement in chess (playing and watching) may be linked to its impact on certain needs, which became relevant or increased their relevance due to the pandemic. Chess is an intellectually complex, strategically demanding and highly competitive game [47] with cognitive, social, and psychological benefits (see [48] for a broad overview). [49] examined the benefits of regularly playing chess for the cognitive and socio-emotional enrichment. In contrast to the comparison group, chess players improved their cognitive abilities, coping and problem-solving capacities and even socio-affective skills, all of which may be beneficial during the uncertainties of the COVID-19 pandemic.

7. Conclusion

The gaming industry seems to be one of the economic sectors that has benefited the most from the COVID-19 pandemic and its prevention measures. In the course of the pandemic a substantial boost in the online activity of players and viewers was recorded for the live-streaming platform Twitch. However, our results indicate, that the streaming behaviour of the established broadcasters on Twitch barely contributed to the overall growth of the platform. Therefore, we assume that the increased amount of content on Twitch during the pandemic is primarily attributed to newcomers. In regards to the increase in viewer numbers on the platform in the course of the pandemic, our findings suggest, that the established streamers benefited more strongly than the newcomers from this dynamic. Furthermore, we could observe a change in broadcasted content during the pandemic, as more non-gaming content was broadcasted. However, the gaming content changed as well, mainly in regards to its theme/setting. Games with *survival setting*, *nostalgic setting* or *real-life activity setting* gained popularity during the pandemic. Thus, we argue that an association between real-life stressors and the choice of setting in video games could be present.

8. Future Research

As research evaluating the impact of the COVID-19 pandemic on Twitch is almost nonexistent, more

well-designed studies with longer observational periods should be conducted. Moreover, the proposed association between real-life stressors and the choice of video game content, more precisely the choice of setting/theme in video games, should be further investigated, as more and stronger evidence is required to determine if the proposed relation can be confirmed. We would strongly recommend an inter- and/or multidisciplinary approach for future research on this topic in order to achieve a deeper, more detailed, comprehensive and holistic understanding of underlying causes of behavioral changes related to the pandemic.

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