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HUMAN–COMPUTER INTERACTION

Human–Computer Interaction

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/hhci20

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To cite this article: Pavel Okopnyi, Frode Guribye, Valentina Caruso & Oskar Juhlin (2023) Automation and redistribution of work: the impact of social distancing on live TV production, Human–Computer Interaction, 38:1, 1-24, DOI: 10.1080/07370024.2021.1984917

To link to this article: https://doi.org/10.1080/07370024.2021.1984917

Published online: 23 Nov 2021.

HUMAN–COMPUTER INTERACTION
2023, VOL. 38, NO. 1, 1–24
https://doi.org/10.1080/07370024.2021.1984917

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Automation and redistribution of work: the impact of social distancing on live TV production

Pavel Okopnyi [a], Frode Guribye [a], Valentina Caruso[b], and Oskar Juhlin[a,c]

[a]Department of Information Science and Media Studies, University of Bergen, Bergen, Norway; [b]Vizrt, Bergen, Norway; [c]Department of Computer and Systems Sciences, Stockholm University, Stockholm, Sweden

ABSTRACT

The TV industry has long been under pressure to adapt its workflows to use advanced Internet technologies. It also must face competition from social media, video blogs, and livestreaming platforms, which are enabled by lightweight production tools and new distribution channels. The social-distancing regulations introduced due to the COVID-19 pandemic added to the list of challenging adaptations. One of the remaining bastions of legacy TV production is the live broadcast of sporting events and news. These production practices rely on tight collaboration in small spaces, such as control rooms and outside broadcast vans. This paper focuses on current socio-technical changes, especially those changes and adaptations in collaborative practices and workflows in TV production. Some changes necessary during the pandemic may be imposed, temporary adjustments to the ongoing situation, but some might induce permanent changes in key work practices in TV production. Further, these imposed changes are aligned with already ongoing changes in the industry, which are now being accelerated. We characterize the changes along two main dimensions: redistribution of work and automation.

ARTICLE HISTORY
Received 8 February 2021
Revised 20 September 2021
Accepted 21 September 2021

KEYWORDS
Live TV production; automation; remote work; distributed work; ecologies of artifacts; COVID-19 implications; TV literacy

1. Introduction

Live TV broadcasting is a traditional media format that continues to attract attention from mass audiences. Although the number of viewers always extensively exceeds the number of producers, production still depends on collaboration among a large number of colocated people with various skills and tasks. The interaction depends on fine-tuned audio communication and visual gestures (Engström et al., 2010; Perry et al., 2009).

This industry has been under pressure to adapt its workflows to make use of advances in Internet technologies and user practices (Juhlin, Zoric et al., 2014). The Internet provides additional broadcast platforms, such as mobile media, and it competes with TV in the form of user-generated social media, video blogs, and livestreaming platforms. Both the new technologies for viewing TV and the new ways of producing video are enabled by lightweight and low-cost production tools and distribution channels.

The way the Internet relates to TV media has received increased attention in computer science fields such as Human-Computer Interaction (HCI) and Computer-Supported Collaborative Work (CSCW), as well as from the area of journalism studies. The interest has been both to unpack traditional practices and to study emergent consumption and production practices between the two areas.

At the same time, the transformation of the TV industry has been quite slow. For example, the transition from production conducted by functionally separated teams, including staff with specific

CONTACT Pavel Okopnyi pavel.okopnyi@uib.no Department of Information Science and Media Studies, University of Bergen, Fosswinckelsgt. 6, 5020 Bergen, Norway.

skills, to production conducted by multiskilled individuals, such as in social media, has been slower than expected (Kumar & Haneef, 2018). It has been argued that the latter workflow lacks production quality.

With the advent of the COVID-19 pandemic and concomitant global regulations on increased social distancing, the TV industry faces a challenge that requires reinterpretation of its relationship to Internet technologies and user practices. On one hand, the pandemic has increased the demand for live broadcast TV News (Castriota et al., 2020), and TV consumption has grown during the pandemic as people are trying to acquire information from reliable, authoritative sources more than from social media sites and influencers (Casero-Ripolles, 2020). On the other hand, the social-distancing requirements impede on the ability to work in large colocated teams in studios, causing the number of staff members in the studio to be reduced. In short, they are asked to do the same or more with less of the resources that they usually have at hand (Castriota et al., 2020).

In this situation, we ask how the TV industry addresses this challenge, especially how TV companies relate to emerging Internet technologies and socio-technical practices. There are indications that these companies have adapted to changes and embraced remote workflows during the first months of the pandemic (Andueza-López & López-Plaza, 2020). Further, they became less hesitant in using public network infrastructures for production and distribution (Coche & Lynn, 2020). TV companies also started adopting hybrid production methods, accepting footage filmed with mobile phones and the use of mobile devices in general in the workflow (Túñez-López et al., 2020). Some changes necessary during the pandemic can be seen as temporary adjustments to the ongoing situation, but others might become permanent in key TV production work practices. Heinonen and Strandvik (2020), in an analysis of the implications of the pandemic on service innovation, make a distinction between how service innovation has usually been driven by discretionary activities aimed at securing their position in a market and *imposed innovation* that is driven by resilience and renewal. In this paper, we focus on how the changes can be imposed and temporary, but still be aligned with previously existing currents of change in live TV production.

On a general level, we see the implications and consequences of social distancing as being part of socio-technical change (Bijker & Law, 1992). Such a perspective stipulates that socio-technical changes are not taking place in a vacuum and are emergent and heterogeneous; they involve a number of different actors, artifacts, and social and organizational arrangements. The changes taking place in TV production occur in a social, technological, and organizational context, where all these aspects are intertwined. In this context, the implications can be seen as relating to ongoing changes and available tools. TV production relies on advanced and specialized equipment and tools, and the way these are used depends on the various workflows and practices in different organizations. These tools can be seen as an ecology of artifacts, following Bødker and Klokmose (2012). The ecology of tools in TV production has been described by Guribye and Nyre (2017) as "the way new and old tools fit together, exist side by side, hook into and supplement each other, and how they compete for the same territory, are redundant, and support more or less the same tasks. A new tool will typically find a niche in the overall work practice and the ecology of tools" (p. 1218). As part of the socio-technical changes in response to COVID-19, there is a need to adopt new artifacts alongside adjusting practices and workflows – tools that have been available in the organizational context, but could be characterized as being in a state of *nonuse* of technology (Satchell & Dourish, 2009) in relation to the production practice.

The introduction of social distancing can be seen as a methodological device (i.e., a large-scale "breaching experiment") (Garfinkel, 1967). Governmental laws or guidelines for such a relevant aspect of social life as the physical distance between people is a disruption of the social order. This disruption rendered visible the organization of work in that the established work practice had to be changed and norms guiding these work practices came under scrutiny.

To study these changes, we interviewed twelve TV and video professionals primarily from TV companies from Europe, Asia, the United States, and the Middle East. Based on these solicited accounts, we provide rich descriptions of how broadcast media adapt to the imposed regulations.

We identify two main themes that conceptualize the current socio-technical changes in live broadcast TV production: redistribution of work and automation. First, we discuss changes to the distribution of work and the new workflows and tools that support these adaptations. Second, we discuss how these changes also drive the move toward further automation of workflows. Third, we discuss how these changes should be seen in light of an underlying current of change that was already present before the new sanctions and norms for social distancing were introduced. In this way, the paper contributes to an understanding of the socio-technical changes that are occurring in the wake of the pandemic. In particular, the concept of redistribution is, as such, a way to see these changes as imposed and partially temporary, but still aligned with changes that were already ongoing in current practices.

2. Background

Traditional TV production usually involves a crew of people who create a broadcast for a mass audience (Perry et al., 2009), which stands in contrast to Internet services, which depend on to an increased extent, user-generated content of people working by themselves (Juhlin, Engström et al., 2014). Most of the interest in HCI and CSCW has been devoted to how the latter intersects with TV, such as the emergence of interactive TV (Obrist et al., 2008), second screen use (Courtois & D'heer, 2012), and peer productions (Yarosh et al., 2016). However, some studies unpack the characteristics of traditional TV production and how it relates to new Internet technologies and practices. Here, the area of journalism studies provides salient contributions. In the following, we first turn to the topic of remote work, and then discuss aspects such as current live TV practices, challenges for non-professionals and how they produce video, emergent changes in professional production, technical aspects of TV production, and production automation. These conditions are all relevant to understanding how the social-distancing requirements during the recent pandemic impact live TV production.

2.1. *Remote work*

Remote work has been a long-standing topic in HCI and CSCW. There have been studies of the use of videoconferencing (Mlynář et al., 2018), distributed work (Koehne et al., 2012; Olson & Olson, 2000), and working over time zones (Tang et al., 2011). More recent studies explore how on-demand workers and freelancers are integrating their work into the work practices of organizations (Blaising et al., 2019; Hui et al., 2019). In another study, Karis et al. (2016) showcase how the Google organization has made remote work options an integrated part of its workflows, and how the company relies on videoconferencing as the key tool for mediating these remote work processes. TV production companies, to the contrary, have been slow to adopt such tools in their work (Coche & Lynn, 2020).

2.2. *Collaboration in traditional live TV broadcasting*

A number of studies presented in CSCW and HCI examined the practice of live TV broadcasting. One study unpacked how vision mixers and camera operators coordinate through video-mediated indexical gestures to support mutual orientation and negotiate shot transitions between remote participants (Perry et al., 2009). Another study explored how live broadcasting often includes concomitant postproduction, such as when providing replays in live sport shows. This highly

time-critical activity is conducted in an uncertain setting and is achieved by using some regularities in the content itself (e.g., the live game) and by splitting up video material with different temporal trajectories on different media (audio and video) or on different screens (Engström et al., 2010).

2.3. *Collaborative nonprofessional TV broadcast*

The availability of low-cost mobile Internet technology has been used to invent and investigate whether current professional practices could be handled by nonprofessionals. However, some challenges have been identified. First, the possibilities to include amateur camera operators in multi-camera live broadcasts revealed how professional operators view things on behalf of the mixer's demands, whereas amateurs add their own interest in viewing for themselves. This double attention leads to a lack of interesting shot proposals for the mixer (Engström et al., 2012). Second, studies of so-called professional amateurs (pro-ams) reveal how learning to become a skilled broadcaster is both an individual task and an institutional endeavor. Organizers of recurrent events need to learn what to do for and during broadcasts, as much as individual producers (Juhlin, Engström et al., 2014). Recurrent production, in which producers cover a series of events over time, seems to be more than a quantitative sign indicating mastery of this medium. Rather, their recurrent production seems to be an important condition for both individual and institutional learning, making the broadcasts possible. Third, the new use of live technology for broadcasting events where the boundaries between producers and viewers were highly blurred (Webb et al., 2016) shows the need to develop new technologies for social communication.

In sum, what has been termed "mobile video literacy" requires competencies in handling the technology and only then in creating narratives and a comprehensible story line for an assumed audience (i.e., what camera angles to use, how to cut, and other aspects of video production) (Weilenmann et al., 2014). The specific professional competencies involved in producing video broadcasts are not easily disseminated to other types of users.

2.4. *Video production in social media*

Nonetheless, there has been tremendous growth in video production by Internet users, and such use of video in social media has been topicalized in CSCW and HCI. The research includes the study of variations in practice among different user groups (Yarosh et al., 2016) or the way in which the live aspect of mobile platforms has been appropriated (Juhlin et al., 2010).

Traditional broadcasters have acknowledged such social media content and have developed ways to incorporate such content within their own production. Their challenge has been to find content for their mass broadcasts, as well as add professional graphic content (Arndt et al., 2016, 2017).

Social media production differs from legacy TV production in many ways. Social media producers often do not have teams of professional workers supporting them, thus sometimes they struggle with managing media assets, such as overlay graphics, especially in live streaming (Tharatipyakul et al., 2020). At the same time, live streams, unlike legacy TV broadcasts, serve as "meeting grounds" for viewers (Hamilton et al., 2014) in which they can interact with each other reacting together to the broadcast (Musabirov et al., 2018). The viewers also interact with broadcasters who have to dedicate some of their resources to community management during live broadcast (Wohn & Freeman, 2020).

2.5. *New professional practices*

The availability of low-cost mobile Internet technology has made it possible to use professionals in new ways as well as provide content for new platforms. In an ongoing trend in news production, journalistic work has become embedded in a process "where the content is developed in front of and in some kind of dialog with the audience" (Nygren, 2014, p. 76). News workers are required to be skilled in more tasks and to be more flexible (Nygren, 2014). Such multitasking also includes video

production (Kumar & Haneef, 2018). Interview studies with journalists in TV production show that the increased requirement to provide fast turnaround for multiple platforms and multitasking has led to an increased amount of content but a decrease in investigative reporting (Higgins-Dobney & Sussman, 2013).

A salient question in the area of journalism studies has been to understand this shift's impact on the skills of journalists. Kumar and Haneef (2018) argue that it could be seen as de-skilling because journalists lack time to become proficient with the new tasks and technology, as compared to traditional tools. Based on a large interview study, Nygren (2014) argues that it instead leads to re-skilling and an increased emphasis "on production and adapting content for different channels" (p. 75). Although this has been described as a ubiquitous trend across the industry, a broad interview study in 2015 argued that it did not occur over the entire industry (Phillips et al., 2009). At that time, only a minority of journalists worked across the media. Phillips et al. (2009) argue that this is most effective in small organizations; in larger organizations, such as the BBC, multitasking seems to "to slow things down and to impact quality" (p. 78).

2.6. *TV production infrastructure*

Video is a demanding medium to work with. Transferring video signals from one device to another, processing those signals, adding graphics, and assembling video and audio signals from different sources into a TV signal that is then broadcasted to viewers requires a complex infrastructure based on contemporary technologies, such as video-encoding algorithms (Ksentini et al., 2006) and networking standards (e.g., Ethernet) (Buysschaert et al., 2020). However, the rising demand for higher quality TV (e.g., ultra-high definition TV) has been posing new challenges to broadcasters (Kostiukevych et al., 2019), as the production infrastructure has to provide video signals with higher definition and frame rates (Buysschaert et al., 2020).

In the wake of these challenges, the TV industry is shifting toward a software-based infrastructure, which implies higher flexibility and scalability, and promises to overcome geographical restrictions to allow TV production to be distributed across locations (Lapierre & Al-Habbal, 2018).

One distributed workflow that has been emerging is remote integration (Coche & Lynn, 2020), which shifts much of the signal processing to a centralized network facility where the production crew is located. In live productions using remote integration, only a technical crew is present at the event location to control cameras and make sure the signals are sent to the network facilities. This centralized production hub is a key part of the infrastructure to accommodate such a workflow. In the case of live sports broadcasts in the United States, most big networks have invested in such hubs. In addition to these large investments, some technological challenges with latency and delays in communication associated with reduced production quality have been seen as major obstacles and risks for adopting this new workflow. After the restrictions imposed due to the COVID-19 pandemic, most networks have adopted remote integration. (Coche & Lynn, 2020)

2.7. *Production automation*

To mitigate the complexity of production, TV companies employ innovations such as production automation (Hussein, 2015), that is, primarily but not exclusively, the automation of switchers – big control panels that producers and directors use to switch between different cameras, cue pre-filmed footage, and add graphics. The idea of broadcast automation is rather old (Freilich & Meyer, 1963), and production automation has become essential to news and news-like TV productions (Richards, 2010).

The effects of automation on the production process are complex as it changes the workflow by delegating what was previously human labor to machines. This change is sometimes met with resistance from workers as they perceive automation as a threat to their employment (Linden, 2017). However, studies show that in general (Arntz et al., 2016) and in the media industry

specifically (Linden, 2017), automation results in the redistribution of labor and complements human labor rather than just replacing it. By "codifying" tasks and substituting human workers in performing routine tasks, automation allows people to focus on the creative parts of work. Thus, automation can raise the value of each worker who performs unique tasks. However, many tend to ignore these positive effects and overestimate the automation's negative effects (Autor, 2015).

The automation of tasks may result in the de-skilling of the operators, that is, workers who observe automated processes and intervene if an automated system breaks down. As Bainbridge (1983) notes, the lack of regular practice of the task might result in the loss of skills essential for the operator to identify the breakdown and to correct the error.

Though the effects of automating workflows have been theorized and studied, research is still needed on the intraorganizational frictions that often accompany automation, how these are being resolved, how well-established practices and organizational norms adapt when automation is introduced, and how automation affects the resulting product (Napoli, 2014).

Automation has been a key topic in CSCW since the 1980s. CSCW partly appeared as a critique of the somewhat narrow perspective and conceptualization of work in office automation (Gerson & Star, 1986; Grudin, 1994). Further, Suchman (1993) criticized the concept of workflows in that they presuppose that formal descriptions of work are comprehensive representations of the work done. These fundamental debates from the dawn of CSCW are still relevant (Retelny et al., 2017) and have bearing on how we understand automation. With automation comes the need to formalize work practices and procedures, and due process (Gerson & Star, 1986) and articulation work (Schmidt & Bannon, 1992) will always accompany these formal procedures.

In a recent paper on everyday automation experiences, Fröhlich et al. (2020) discuss some of the implications automation may have on how we interact with technology in everyday life. They emphasize the way the interaction with automated systems is a matter of formalizing procedures and is more similar to end user programming than what is common in interaction with other technologies. The interaction between user and automated system becomes non-continuous and implicit. Thus, automation opens for substitutive experiences, as it frees the user to do other tasks or activities instead of continuously operating the system. While the authors say that these points are mostly relevant for everyday use of technologies, we argue that they are relevant also for more specialized and professional workflows involving trained personnel (Fröhlich et al., 2020).

3. Methods

We have conducted and analyzed twelve remote semi-structured video interviews with video professionals, including personnel working for high-profile TV companies in Europe, Asia, the Middle East, and the United States. In general, in the interviews, we focused on the changes to the working environments and routines of video workers due to social distancing. We discussed how these changes affected their work, and the work of TV companies and organizations in general, from a socio-technological perspective, that is, focusing on the amendments to workflows and tools that had to be applied. We also discussed the future of TV and video work with the participants. We transcribed the interview data and conducted thematic analysis in three iterations.

3.1. *Sample*

A combination of convenience and heterogeneity was applied as a sampling strategy. Heterogeneity was specifically applied to include participants from different TV stations and roles. Our strategy was to find people who worked at legacy TV production organizations and had relevant knowledge and experience to our research topic. We conducted 13 interviews in total. However, one interview did not give any relevant information as the interviewee did not have any relevant experiences with automation or redistribution as we were focusing on in our analysis. Thus, we excluded this interview from the analysis.

Table 1. Interviewees details.

	Country/Location	Current occupation/Background	Organization Type
I01	Northern Europe	Video editor, camera operator/TV editor, operator, producer	Higher Education
I02	Northern Europe	TV web editor, producer	National Broadcaster
I03	USA	TV studio technical director	National Broadcaster
I04	Western Europe	Specialist in automation, producer/TV director	International Media Technology Provider
I05	Western Europe	TV software development manager/TV and Video producer	International Media Technology Provider
I06	Europe	Product manager, field producer	International Media Technology Provider
I07	Southern Europe	TV journalist	National Broadcaster
I08	Middle East	TV journalist coordinator, manager, field producer/ Journalist	National Broadcaster
I09	Southern Europe	Coordinator, Manager	National Broadcaster
I10	Northern Europe	Head of Content, anchor, producer, manager/TV director, Art Director	International Media Technology Provider
I11	Asia	Head of the department for studios	National Broadcaster
I12	Latin America/Northern Europe	Film Director, producer, editor/TV editor	Higher Education/ Independent Filmmaker

The resulting sample (n = 12) included two journalists and ten managers and directors with different levels of expertise. Seven of the interviewees currently work for TV companies. Two worked for TV companies and currently work in the video production industry. Five interviewees worked for TV companies previously but currently work in adjacent industries, such as software and hardware development for TV studios. All interviewees, except I02 and I07, have very diverse responsibilities which are not limited to their formal roles and job positions. For example, I10, who is formally a "Head of Content," also participated in different productions as anchor, producer and manager. In Table 1, we list relevant roles and functions which interviewees performed during the pandemic, as well as their background and types of organizations they are working for. All participants, except I01 and I12, participated in TV content production. I01 and I12 worked with video production during the pandemic in another setting (higher education), but still provided us with valuable variation and supplementary views on the trends and future of production workflows. Participants I04, I05, I06 and I10 were not employed by TV companies during the pandemic; however, they worked closely with TV companies and participated in TV production in different capacities during 2020. Each interviewee had at least several years of experience of work in the TV industry.

3.2. *Data collection and analysis*

Data collection was carried out through individual semi-structured interviews that focused on participants' opinions and experiences in the TV industry. Two participants were interviewed in Italian, whereas other interviews were conducted in English. The interviews lasted from 30 to 60 minutes each. In addition, we had informal conversations with representatives of a TV technology provider to identify new ways of organizing live video broadcasts in the current situation. In the beginning of this study, these informal conversations helped us to develop the interview guide and identify interesting topics which we focused on during the interviews. We also used informal conversations to clarify professional terms and learn about specifics of certain technologies, such as TV networking standards.

In the semi-structured interviews, we mainly focused on the following questions: What is your daily routine and how did it change during the pandemic? How did the workplace change during the pandemic? What tools do you use to communicate and collaborate remotely and how do you use

them? What challenges and opportunities did pandemic introduce to your work? Do you think there will be any long-term consequences of the pandemic?

We must note here that the topics we discussed were considered sensitive as we were touching on subjects such as employment/unemployment and replacement of human workers due to workflow automation. Some interviewees expressed concerns about being identified even by a brief description. Thus, we do not specify their nationalities, nor do we name the companies they work for.

When the participants gave their consent, the interviews were conducted and video recorded using videoconferencing tools such as Microsoft Teams and Zoom. We transcribed, anonymized, and translated the available interview recordings into English. The study was ethically approved by the local institutional review board.

We analyzed the interview data by adopting a thematic analysis methodology in collaborative online sessions, and followed the six steps as identified by Braun and Clarke (2006): (1) reading and searching for meaning and patterns to familiarize yourself with the data; (2) generating initial codes where themes are data driven; (3) searching for possible themes; (4) reviewing themes by refining the data extracts; (5) defining and naming themes; and (6) producing this paper. We analyzed the data in three iterations. In the first, we searched for meaningful patterns and generated initial 72 codes. In the second iteration, we extracted eight general themes, which we defined and named. In the last iteration, we reduced the number of themes by filtering out less relevant and extracting one additional meta-theme (the future of work). The analysis was performed mainly by three researchers in collaborative remote sessions, the fourth researcher participated also in the second iteration.

4. Results

Certain adaptations of the work practice can be supported by adopting existing tools and applications, such as using Skype for live interviews. Other adaptations require deep infrastructural change, for example, the transition to Internet Protocol (IP)-based technologies. At the organizational level, these adaptations can involve changes in scheduling and role assignments or the knowledge and skills required to run operations.

The social-distancing rules disrupted the ordinary workflows in TV companies. Some productions, such as sports events broadcasts, had to be canceled because events were canceled and the content disappeared per se. Other productions, such as TV series, had to be postponed as it became impossible to organize a shooting with so many people involved.

In our data, we identify five major topics. In this section, we present the results in the following manner: First, we describe how TV companies adapted their workflows, specifically, how they employed remote work. Second, we address the topic of transformations in TV literacy. Third, we describe how TV companies adopted production automation and the implications therein. Fourth, we illustrate how TV companies perceive broadcast quality and how this perception changed during the pandemic. Fifth, we present interviewees' speculations about the TV industry's future and the long-lasting effects of the COVID-19 pandemic.

4.1. *Redistribution of work*

TV companies had to rapidly adapt remote production workflows to keep the production running. In this section, we describe how the nature of the work for different TV workers changed with the adoption of remote technologies.

To comply with social-distancing regulations, TV companies had to restrict access to buildings, allowing only "essential" personnel who are required to keep the TV broadcast running:

> I work in the control room. As a technical director, I have to because this is where the big switcher is. In theory, it can be done remotely, but, in practice, we have to be by the console. (I03)

The number of people in a control room had to be significantly reduced, from ten to eleven people to five people. Some workers, who were still required to work on the live production but could not be in the control room, moved to other rooms and communicated with their colleagues via intercoms and Voice over Internet Protocol (VoIP) services. Technical staff, who still worked on-site, had reduced mobility in that they could not change shifts or switch teams. Teams became segregated and isolated from each other.

In addition, the reporting workflow changed, as it became almost impossible to send a filming crew together with a journalist to a site. One of the interviewees, I08, who is responsible for managing field reporters, now tasks them with filming the footage by themselves with mobile phones.

TV anchors started hosting their shows from home, relying on the Internet connections that are shared inside the household. I03 described one such case:

> We have a show and the anchor has a home studio. Right when we went on the air one night, his connection suddenly dropped. His picture would freeze and pixelate. It turns out, it was because his teenage son was downloading software on the Xbox.

This quote illustrates how the socio-technical space created for doing the work remotely – from home – is a shared space. Juxtaposed with the social space of the home, the socio-technical space is dependent on what others in the household are doing. This setting is in stark contrast to how professional TV studios are organized as fully controlled settings for the purpose of recording and transmitting, including controlling noise, light, camera positions and angles, and network connections.

The redistribution of work in TV production involves adopting new tools, for example, video-conferencing services such as Skype, Microsoft Teams, and Zoom, in the production process. Where TV companies previously relied on sending a crew and using specialized equipment, they are now turning to such easily available software services.

The redistribution involves not only using these new tools but also accommodating and supporting remote work, as the social-distancing requirement mandates fewer people crowded together.

> The situation forces us to explore the potential of tools such as Microsoft Teams and Skype—this potential was not fully realized previously. Before that, to interview a person, they would go to this person with equipment and a camera operator—now they just call. (I07)

Further, an interviewee pointed out that this way of producing content actually makes the production process leaner (more lightweight):

> Doing Skype interviews from homes reduces production costs significantly because they need less work with light, camera, sound, and studio decorations. Also, it allows having more people than the studio could accommodate even without social distancing, as there is no need to prepare microphones and places for all guests. (I07)

This redistribution of work came with challenges connected to adopting the production process to incorporate these new workflows:

> I would say that in March, it was hard; today it is not, because the technology companies like Teams and Zoom have made this a lot easier. I just did an interview with five people at [TV Company] at the same time, all from their own homes. So, [I have] separate [video and audio] sources for every single person and myself, and, in March, that would have been very hard to do; now it's just a matter of getting everybody on Microsoft Teams. I'm able to take the Teams, turn that into an NDI source, and then bring that as individual sources onto my switcher. It becomes very easy. A quick level of innovation has happened in the tech industry to enable these things that were very hard and very expensive to do just a few months ago. (I10)

In this quote, several issues are addressed. The interviewee described how they are incorporating the new tools to allow for remote participation. In addition, technical changes have been made to the videoconferencing software to enable signals to be transferred directly into the switcher (a hardware/software piece that selects video and audio sources to be broadcasted). These signals can be

transferred directly to the controller for manipulation and editing. Another point made in this extract is how a transition to an IP-based tool network device interface (NDI) for production is key in this process.

In the process of accepting new tools, the challenge is to maintain the quality of signals and image resolutions that are now transmitted over the Internet while relying on the Internet provider's connections, method of encoding pictures, and so on:

> It can easily be shared outside the production building, even on a pure Internet connection. It technically is possible to have an NDI signal from Milan to New York without a major problem if the bandwidth is good enough. (I06)

The transition to an infrastructure that more easily supports a distributed and remote workflow of TV personnel, such as anchors, is further described by I06:

> Your workflow is restricted inside your walls because of your infrastructure and, because of COVID-19, because people are working remotely, they need to have a signal outside of your building, and it becomes a priority.

While some of the work was done remotely, the redistribution was also done inside the buildings of TV broadcasters, as I03 described: "Some of the producers work from home, we have some of the producers who work from the isolated rooms, but I work in the control room." With this redistribution, they need to keep a back channel open for coordination and communication between the team members:

> In the local studio, we have an RTS intercom panel, but for our connections to the outside world, we can have Internet tools as well as a cell phone or even landline; it depends. (I03)

A transition to incorporating remote work into the workflow of the production also required training and supporting the remote participants. This support included giving instructions on how to set up lighting, place microphones, and use cameras at home, as well as how to best operate the equipment at hand. These instructions varied according to the setup and expected level of quality of the production. In one case for a big sports event production, they put together standardized kits of equipment, including a two-camera setup and a light setup, to be assembled at the remote location:

> For the NFL draft earlier this year, they did the entire thing as a remote production. In fact, it was run out of the director's garage. But they knew who they were going to be talking to way ahead of time. They knew they were going to have an audience of 30 or 40 million people, so they built standardized kits that they could send to every single person they would interview, including a light setup and a two-camera setup, that they could just put down and turn on, and then the people at the NFL could remotely [log] in to it and do all the settings changes just to make sure that it's okay. That way, they can control the quality of the interview. That is what we're doing now too. We give them [interviewees] a small PC and a PPPoE [Point-to-Point Protocol over Ethernet] camera and a light ring, so [they] have the same setup. When I do an interview with them, I can log in to that computer remotely, adjust the camera, adjust lighting and all of that stuff, and set everything up so they don't have to do anything except sit there and talk. (I11)

In this quote, we see how different competencies and responsibilities are redistributed with the transfer of work from studio workers to guests and interviewees. This redistribution also involves adopting new tools into the distributed workflow, in this case, mobile devices and Internet services.

4.2. *Transformations of TV literacy*

The current situation makes explicit alterations of the distribution of skills among those who take part in a TV broadcast, as well as where these competencies are provided. I06 described a situation before COVID-19 where there was an elaborate separation of individuals with specific roles, related to certain skills:

> The main problem in the TV market is that the knowledge of other employees is so vertical. A cameraman is just able to work as a cameraman, and the video mixer as a video mixer.

I07 stated that to interview a person, they would go to this person with just equipment and a camera operator. This method of distributing skills among all involved (i.e., interviewees, journalists, and technicians) is in flux. Our interviewees gave accounts of TV productions where skills are redistributed. When it comes to the journalists, I04 stated that they have obtained new skills in handling technology, such as using digital applications:

> When I started working with journalists, they didn't have any clue about anything technical, but today anyone knows how to run an application and how to make a clip.

The redistribution of skills is most evident in how the interviewees are delegated the task to be both cameraperson and technician:

> In some sense, the work became easier because before we would be required to send a filming crew if we wanted to do an interview. Now we just call the person and ask them to record the answers with their phones and send the file. (I08)

When it comes to the technical staff with specialized skills, the situation is also changing:

> I think at some point the big change will be really in the culture behind the employees in TV. I think the new generation that TV channels will look for, especially because of what happened […] you will look for a guy that will [have skills to] manage a video gallery with audio mixers, vision mixers, and will have a clue about how to use a camera. (I06)

Thus, the technical staff is required to extend their skills beyond those of previous functional separations in the organization. The skills have been required in two different ways, that is, either through specific training in broadcasting or by engaging with consumer technology and services online.

The journalists that work with remote productions "need to have the skill, people that are able to use a camera, to edit, to send you the content" (I06). They are occasionally provided with formal training. I08 stated that they "did a two-day course for journalists teaching them how to use smartphones as cameras." As discussed previously, the redistribution of work depends on new skills among the interviewees. Journalists have become instructors and producers, and the interviewees have become production assistants and camera operators:

> We had to teach reporters how to film with phones so the reporters can teach guests how to film themselves with phones when recording answers. We teach them how to place the camera, what angle there should be and distance, and where to sit so the lighting would be good enough. (I08)

The skills that are used by interviewees, journalists, and technical engineers in current TV production draw in various ways on the participants' previous engagements with consumer technology and online services. Skills required online also change the competence of the technical staff, from legacy TV specialists to social media content creators, such as YouTubers. I11 described it further:

> I'm more interested in finding new, creative ideas on how we can implement things, for example, if they do YouTube on the side, they know smarter and cheaper ways to actually produce a video compared to someone who went through a traditional [production] route. They'll be like "oh I need to have very good quality, and I need to use this equipment specifically to produce this because that was what I was taught" […] I think people who went through that [nontraditional] route will have a different mindset. I think it's a good thing for people in TV to have an understanding that maybe we can tap on the skills from people who are from that route, not the traditional route.

Finally, the increased distribution of work means that those who are in charge of specific tasks might lack specific competencies, that is, skills that had been available in previous productions but are no longer at hand within the new type of broadcasts. I11 pointed specifically to how graphics require special skills that are not provided for in a distributed setting:

> We have to think how we can be better than the online platforms. We are paying more money, so how can we improve our content? Something that the [social media creators] can't provide. We have a lot more graphics

> presentation. We use a lot of graphics to present our stories. It's not something you can easily do in a home setup. It's something you can do in a big studio.

Furthermore, it is argued whether YouTube production experience is enough to produce a professional broadcast. I06 referred to TV as "a language" and stated the following:

> At some point, you need to do the proper thing, even if you use mobile phones. You need to know how to use the light and how to use the microphone because you need the proper quality.

In this quote, I06 emphasizes that there is a certain threshold in skills between professional video workers and other content creators.

4.3. *Automating production*

During the pandemic, some TV companies turned to automation as one of the instruments that allowed the production of content with fewer people in the studio:

> BBC is entirely automation, CNN is entirely automation, and Fox News is entirely automation, so it's become the norm now to go with this. (I10)

To understand the impact of COVID-19 and the role of automation, it is necessary to recognize live TV production as a labor-intensive process that involves many roles and tools. I03 described the control room in their TV company as the following:

> You have the person that is controlling the switcher, that's one or two people. You have the person that is controlling the audio, that's another person. You have a person that is controlling the graphics, that's another person. You have a person in the studio that is running the camera, that's another person. You have an engineer that is watching the video signals, that's another person.

The social-distancing restrictions have had direct consequences for this workflow organization. The inability to have workers in their usual places combined with the rising demand for new content created a situation in which automation becomes a very welcome solution:

> When you suddenly cannot have a lot of people in the control room, then what's your option? You still need to produce content because actually, at this moment, you have a captive audience that is sitting at home eager to have something to consume. You have to go to automation. It's the only way to survive and continue being able to produce content. (I10)

Automation in this context is about programming software to handle some tasks that normally are carried out by human workers:

> These roles can be combined into a single action by automation. So, when I say "take on camera 1" in the automation system, the microphone for camera 1 automatically pops on, and the camera moves over by robotics to the place that it needs to be. A graphic could come up saying that person's name on camera 1 at the same time, and the switcher is going to change a source. (I10)

The possibility of doing this has increased since the cost has decreased. Automation draws on a continuous digitization of production functions, which has reduced the need for specialized and expensive hardware:

> The smaller broadcasters are the last to really get into this because automation used to have a very steep price point in the past. It was very complex. […] The idea of software-based automation is lowering the price point and lowering the entry point. […] and it's not just the automation being software, it's the fact that all of the components are becoming software. (I10)

Furthermore, automation draws on an understanding and a practice where the work described previously is seen as repetitive and even boring:

> The show is always the same. [It is] the content that is different. You have the intro in the same way. You have the first shot in the same way. The camera is moving in the same way every day, four times per day. (I06)

When I06 referred to the show always being "the same," this is from a production perspective, which differs from the "content" that varies over time. I06 stated that even new shows repeat the same production principles: "It's just the same new show; it is so boring. It is always the same concept."

The interviews also discussed the consequences of this socio-technical shift. First, it will lead to broadcasts that in their structure are decided before they go live. This in turn requires that the current informal rules are made explicit and are decided upon in advance. I03 stated that "producers will be responsible for creating more of their content, not only for video clips but also for graphics. They would have to have a more structured rundown." I11 stated that their company tried to employ automation for years, and one of the major restricting factors was the negative reaction of the studio workers who "felt very handicapped with automation, so they couldn't produce the show that they wanted."

Second, the technology can lower costs for TV production, which would lead to redundancies in that specific case, as argued by I03:

> I have a feeling that this might cause lasting changes to the way we work because we are now finding out that we can automate some of our shows and eliminate staff.

However, I04 argues that there is a latent demand on the industry to produce more content, which will compensate for the leaner production:

> People most of the time are afraid about automation because they think that it's going to do everything, and it will take their jobs, which is not really correct. I know that the financial part they see, "oh we're gonna take out some," which is not wrong, but each TV station wants to produce more, and if you want to produce more, you cannot […] think about doing production without automation in the future.

Third, the programming of the machines could have been done in the wrong way, or the broadcast could need adjustments that are out of the scope of the current automation. However, I10 argued that they are less prone to errors than the current setup:

> [Company] has done a study on the effects of automation for their on-air errors and they have found that year to year going from nonautomated to completely automated, their errors have been reduced.

At the same time, handling errors and breakdown in the automated TV production requires a setup of numerous backup systems, procedures and countermeasures:

> We have multiple layers of backups. Number one [is], if, for example, the [automation system] server itself is having issues, we can swing it to our backup server immediately: it will take five seconds and then there would be minimal to no impact on air. So that is one layer of backup. If the automation system goes down, we have a procedure on how we swing to manual operations as well. The tricky part about that is getting the manpower in. If it is during the day, it's not too bad: I can just pull people in and run the show. In a really worst-case scenario when the entire control room is down - that's a whole different backup system. (I10)

4.4. *Broadcast quality*

Another topic addressed by several of our informants was how the new ways of working had implications for the quality of the product they were making. They reported a changed attitude toward the need for high quality in the content. Many said they had to accept a lower quality due to the new tools. "I do the best with the equipment I have," as I01 put it.

There is a distinction, however, between production quality and journalistic/content quality:

> What broadcasters are finding out is that in the past, they were very concerned about the quality of the video and the quality of the interview. They wanted to have this nice 4K camera shooting their interview subject because it's going to look better for the presentation; the audience is going to like it better. But really, the audience is just interested in what the person has to say. So even though we're not getting that same 4K quality of having the production crew on-site at this person's house, uploading to the satellite and coming back, and all these things, we're just bringing them in via Zoom or Skype or something. They're still getting the same story

> and that has become acceptable for the audience. And that has also changed, how much production value broadcasters actually have to put toward something in order to bring the story to their audience. (I10)

As we can see in this excerpt, there is a changing attitude toward what is important for making quality TV, which is not only tied to notions of using the best, top-rated, industry-grade equipment. Further, interviewees pointed out that there is also a shift in the expectations of the audience. They are getting used to seeing videos and clips that are not made with the best resolution or perfect lighting. This trend has been following the social media distribution of content:

> The quality is lower than it used to be, but it was getting lower anyway because more and more reports and interviews were done with these technologies, mobile, for example, breaking news. So, people were getting used to seeing reports and interviews in lower quality even before Skype became a mandatory tool. (I08)

Still, some also pointed out that there is a need for a certain threshold in quality. There are still some standards that they try to meet to stand out among other video producers, such as pro-am content creators. For example, I11 explained how they, the national broadcaster, use graphics as a tool to stand out from YouTubers and social media creators (see earlier comment from I11).

The new experiences with lower resolution, using videoconferencing tools and mobile phones, put the demand for expensive equipment and setups under scrutiny:

> Because of the union of the TV editors, they had to create the editing room with the proper audio noise leveling, so they spent something like 100,000 pounds for every editing room because of the noise, because of the light. Now, during COVID-19, all the editors are working from home with the noise, with the light, with the kids, and they are doing the exact same quality of production, so why should we be back? (I06)

We mentioned previously how TV companies try to preserve quality by teaching remote participants how to use their mobile phones as cameras. With the varying quality of signals coming to the editor, there is a renewed need to manipulate and process the signals:

> You have to deal with every single connection now. I have some color correction tools here, and I could do a live color correction to make it a little bit better, but it's still … you have what you have. (I10)

The acceptance of a lower quality when moving to remote production was also a recurring theme, as indicated by the "you have what you have" statement.

4.5. *Future of work*

When asked about possible implications for the future of the TV industry, each interviewee said that their workflows will definitely change in some way when social-distancing restrictions are lifted. In this section, we provide an outline of the possible changes that will occur in TV and video production.

I01 said that they would consider working from home when it comes to small projects, that is, short videos and stories, because small projects can be done completely remotely, without physical meetings with other participants. I06 speculated about the need for TV companies to have all the workers they used to have in the office:

> Right now, there is less than one-third of the people inside a building, and they do exactly the same level of production, so why should all those people be back in the building? Is there a reason for that? Is there a reason for all these people to travel again? To be in the car in a traffic jam?

Others, though, said they would prefer to return to the work in the studio "because we need to work as one team" (I08). However, that does not imply that their workflows will remain intact. I05 agreed with that, saying that it is easier to have work discussions and meetings face-to-face.

I08 suggested that their production company will rely more on mobile-produced content, that is, footage filmed with mobile phones by journalists, pro-ams, and amateurs. This more generalistic approach to TV production, which demonstrated its viability during the pandemic, is something that TV companies will look for in their personnel. For example, I11, whom we quoted previously, is

more interested in finding new, creative ideas to implement and is more interested in people with YouTube production experience than those with a traditional production background. I06 expanded on this topic, saying that the hyper-specialization of TV professionals ("vertical knowledge" [see earlier quote]) is a major problem for TV companies, including how it will be addressed in the future by hiring more multiskilled workers.

I11 also speculated that TV companies would be looking for video workers who possess more diverse skill sets and are familiar with nonprofessional and pro-am production tools and workflows, such as YouTubers and livestreamers, because TV companies are starting to accept the quality that amateur/nonspecialized tools provide:

> This is what the broadcaster will look for in the future. In terms of the broadcast quality, in the last three months, everybody was using Skype on a mobile phone because the content wins over what you see. The content is much more important than the quality you show.

Over the course of the pandemic, automation has become more and more popular and prominent. For example, several big TV companies with which I10 works have gone completely automatic over the course of just several months.

I06 said that there is an ongoing discussion among professionals: "We talk much more about remote production, especially for sports." I11 speculated about the future of remote production, remarking that not needing to travel to film an event would possibly become "a new norm" if the online event format maintains its popularity in the future:

> I feel like people are fond of these online events. We no longer have to travel to attend conferences. It's much cheaper and much easier to organize and that's why we are looking at a more long-term plan for how we can move forward without all these restrictions and without tying down our studio resources for this.

Aside from events, conducting interviews will also happen online more frequently

> Our reporters no longer conduct interviews out in the field. As much as possible, they try to do it via Zoom, so they're able to record it on their PC and send it to be edited. I think that those are some changes that would remain, but of course when it comes to our VIPs, we will still send a crew down to do the interview, but I don't really see us reversing any new changes that we implemented during this period. (I11)

The problem of limited resources, such as fewer incoming video sources (e.g., Skype calls) is addressed by the shift in technologies that continues to happen during the pandemic. In particular, there has been a shift from hardware-restricted to software-based protocols, as I04 elaborated:

> This is where we are going, and then we can talk about the NDI and the future. I don't know if it [the future] is the NDI, but it's not SDI [serial digital interface] anymore. SDI, I think, will just disappear very slowly. We still have some years with this SDI because the whole world is using SDI. It's not [going to change] in one day.

Another possible shift that is being adopted in some companies but not yet embraced by big TV studios is the employment of cloud-based production tools, which allow TV workers to produce content from various locations via the Internet. It is suggested that cloud-based production technologies can dramatically change the work for TV professionals:

> If you're in the US and you have the best person to do the task, but he lives in LA and you have to fly him over to New York four times a week to do that task because he likes living in LA, suddenly [by using the cloud] he doesn't have to fly anymore. (I05)

With these newly established remote workflows, participation that does not require traveling becomes more readily available. The benefits from cloud-based technologies are apparent, as they allow production to be scaled according to requirements:

> The power of software is that it allows you to have either one copy running or fifty copies running on [the cloud platform]. […] You can scale up and down based on the needs of one specific day. (I06)

However, not all TV companies are ready to adopt cloud-based production due to cybersecurity concerns:

> It's very interesting software, but our concern is always cybersecurity. We are a national broadcaster; our cybersecurity measures are very strict. Even internally in the building, we have a lot of restrictions, let alone producing a show from an outside location and tapping into our network. Those are some of the challenges that we will experience if we explore this route, but definitely, it is something that we want to look into. (I11)

In sum, our interviewees agree that after COVID-19 pandemic is over, TV production companies will change their working practices and accept more general public technologies in their production workflows, as well as new technologies, such as cloud-based, which allow remote workflows.

5. Discussion and implications

The statistics of live news broadcast during the pandemic shows (Castriota et al., 2020) an increased demand for live news TV. At the same time, the restrictions on social distancing meant that some of the previously available production resources are no longer available, which represents a challenge for the industry i.e., the COVID-19 challenge. In the following, we discuss how the TV industry address it through redistribution and automation, as well as the long-term implications of these strategies and how they interact.

5.1. *Addressing the COVID-19 challenge*

As argued by Guribye and Nyre (2017), live TV productions depend on an ecology of advanced and specialized equipment and tools, which are used in various workflows and organizations. The strategies selected add to the ecology of tools for TV production (Guribye & Nyre, 2017) in different ways, drawing on alterations of social practice as well as changes in the use of technology. In the following we summarize the identified general strategies, i.e., automation and redistribution.

5.1.1. *Redistribution of work, control, and skills*

In CSCW and HCI the concept of remote work is important to denote how mediated interaction across distance is happening (Karis et al., 2016; Koehne et al., 2012). Instead, we use the term "redistribution" to characterize what in many cases are adoption of remote work in live TV production. The concept is more encompassing than remote work and is meant to emphasize how practices change and how these changes involve more than adopting remote work per se and specific video conferencing tools. The concept of redistribution of work characterizes how practices are changing over many dimensions, and in particular it denotes the imposed and temporary adaptations done as a response to the social distancing measurements.

In this case, redistribution introduces new tools and practices into the ecology, i.e. ubiquitous Internet services. The use of Internet services such as social media for user-generated content, which lately has come to include video content, is abundant. When camerawork is redistributed to journalists, guests and other nonprofessional operators, it draws on this widespread literacy. The TV industry hooks into a different ecology of tools which includes general-purpose devices such as mobile phones.

In the studio, the remaining staff stuck to their traditional tasks but spread out in the office building, which was made possible by the use of voice communication technologies. The story is different when it comes to professional work outside of the studios. Here, the journalists had to learn new skills when camerapersons were no longer available. This shift from specialized tasks to multiskilling follows a trend that has been long discussed in research (Kumar & Haneef, 2018; Nygren, 2014; Phillips et al., 2009) and where there has been a discussion on the barriers to such a change.

Another, more remarkable, redistribution of work occurred outside the studios, when guests in TV shows were asked to film themselves. They instruct their remote guests on how to sit in front of the camera and where to sit in the room in relation to light and sound sources. In some cases, they send special hardware kits with light sources and cameras and provide detailed instructions

regarding how to use those kits to ensure the good quality of the produced content. In these cases, the professional work of an entire team was redistributed to a nonprofessional person behind the camera.

The redistributions occurring outside the studios also came with new demands, that is, providing journalists and participants with new skills. Journalists were provided with short courses where they were taught how to use their mobile phone to film the footage by themselves. Nonetheless, it was noted that the redistribution depended on learned skills that had been acquired in situations other than during formal education. Interviewees noted that during the pandemic, the redistribution could draw upon the fact that skills in using Internet services and mobile devices were ubiquitous. This was evident in I04 stating that all journalists these days know how to use an "application."

Still, we argue that the extent to which it depends on an increased familiarity of users, outside of the studios, needs to be recognized. Internet users have become increasingly proficient in photography through using services such as Instagram and Facebook (Juhlin, Zoric et al., 2014). They are even becoming skilled in producing moving image productions through videoconferencing services, Twitch, YouTube, and so on (Hamilton et al., 2014; Yarosh et al., 2016). Thus, the redistribution depended on the skills acquired for reasons unrelated to TV production.

The redistribution of specialized technical tasks, such as from camerapersons to journalists and nonprofessionals, implies that professionals decrease their control over broadcasts and must tolerate other standards that are more aligned with Internet practices, such as a TV host needing to share the local network with a gamer. A similar shift of control also occurred with the increased use of Internet services in broadcasts, such as videoconferencing technologies (e.g., Skype and Zoom). It is notable how these Internet service providers swiftly adapted their protocols to make them accessible for TV technologies such as NDI when the latter needed it during the first phases of the pandemic.

We also note that graphics production might have been distributed in the office facilities of the broadcast studio to meet social-distancing requirements, but the technology remains under control of the traditional broadcasting ecosystems. When camerawork, lighting, audio recording, and so on are shifted to ubiquitously available technologies and production is redistributed from specialists to multiskilled professionals and even to amateurs, it is argued by our interviewees that graphic production will continue to distinguish broadcast TV from online video production.

5.1.2. *Automation, planning and error reduction*

Automation is a prevailing trend that becomes increasingly available in studio work, when the industry implements standard digital technologies of various kinds, i.e. technologies which can be used for TV production through software applications. It draws on a shift from specialized digital hardware to general-purpose hardware, as well as on new specialized communication protocols that can be used on the Internet.

Previously, such automation has met resistance in the TV industry since, as noted by our interviewees, TV workers were "afraid" and "felt very handicapped." This experience of lack of capability and control over the production process might stem from the transition from continuous operation to implicit interaction with an automated system (Fröhlich et al., 2020). However, the imposed social distancing restrictions seem to have decreased institutional hesitations. We've been told about major TV companies automating much of their production during the pandemic.

Automation changes the "normal" working process, as TV workers have to adopt new workflows that require much more work in the preproduction phase. For example, workers are required to plan the work and develop scripts for automation systems, that is end-user programming (Fröhlich et al., 2020), and establish backup systems and breakdown-handling procedures. Thus, the production process becomes more formalized. This formalization should also be approached with caution, as it might overlook how the emergent work requires due process (Gerson & Star, 1986) and articulation work (Schmidt & Bannon, 1992), notwithstanding how detailed the formal representations are (Suchman, 1993). This formalization also reduces the room for human errors during live broadcast as production automation implies TV workers giving control over broadcast to a machine that

executes a set of predetermined commands. The participants in our study claimed that automation actually reduced the number of errors. We do not know, however, if the errors are getting more or less severe. Further, as I10 mentioned, there is a need for establishing complex backup systems and finding substitute workers rapidly in the case of automation system breakdown. At the same time, our informants say that automation allows TV companies to redistribute workers, who are now freed from continuous operating by automation, between productions and can produce more content as a substitutive activity (Fröhlich et al., 2020).

In sum, taking automation and redistribution into account, we see that the handling of the COVID-19 challenge has a broader impact on the work outside of the studio than inside. The studio workspace seems to be a resource that is used to resist multiskilling, or a barrier, if the trend is seen as positive.

5.2. *Long term implications for TV workflows*

The question is then what will stay of these changes and what will go back to how it was before the pandemic. In other terms, the COVID-19 restrictions on social distancing can be seen as a push (Nimako & Ntim, 2013) that fuels those trends. But what happens when this push is no longer available? We have identified a number of topics that can either pull, or more vaguely "moore," (Stimson & McCrea, 2004) the industry back toward its traditional workflow. The factors that pull the industry toward both automation and redistribution includes those of availability of general-purpose technology; multi-tasking, wide skilling and changed viewing experiences. The factors that "moore" the work flows back into traditional studio work include lack in skills, need of control and data security.

5.2.1. *Factors that push the workflows toward redistribution and automation*

We argue that the TV industry will continue to be pushed in the current direction because of changes in technology, production, and viewing practices. As mentioned above, both automation and redistribution, from a technical perspective, draw on a shift from specialized to general-purpose technologies.

This shift *lowers the costs* of TV production but also makes it possible to *do new things*, e.g., scripting studio work in software or a more mobile journalistic practice. From a production practice perspective, there is a push by an *increasing number of producers* who are getting skilled in live video broadcasting online (Hamilton et al., 2014). From a viewer's perspective, there is another push that supports the redistribution trend. As I10 noted, the TV industry has always striven for higher broadcast quality. However, the Internet ecology has created *viewing experiences with lower image qualities*, made available on consumer Internet services, including mobile devices and Wi-Fi connected laptops. We argue that the "tolerance" of the quality of pandemic TV productions depends on this new ecology of tools and Internet practices.

5.2.2. *Conservative factors*

There are obviously factors that can make the industry pull back, or at least moore the changes back, to the state the industry was in before the pandemic. Participants' current production *skills might not always be sufficient*. As we mentioned earlier, during the pandemic, TV workers had to instruct their remote guests, as well as provide them with better equipment. It might be argued that this has not been sufficient. Having people back to the studio will make it *easier to control* all these features. The resistance to automation, might re-occur when the physical locations are open as before, as might the resistance to the lower broadcast quality imposed by the use of general-purpose Internet services and mobile devices. This resistance can become stronger as the physical restrictions are ended. *Lack of data security* is another important concern when considering cloud-based production technologies from becoming widely accepted in the TV industry. Cloud-based production implies the possibility of redistribution of traditionally in-house specialists, such as graphics operators and producers, to

remote locations. This redistribution introduces new uncertainty as the production will rely heavily on public infrastructure, the Internet.

5.2.3. *Interdependecies*

We have previously discussed automation and redistribution either as parallel trends, or in some sense even dependent on the same underlying Internet technology. In the following we will discuss if there are characteristics that make it difficult for both to sit together at the same time. We learned that both emerged as strategies to address the Covid-challenge. But will they continue to emerge side by side or are they affecting each other? This is perhaps the most critical topic to address for the industry. Automation is very much an insiders' trend where the professional TV producers programme the machines to do their routine work. Such routines emerge out of their standardized practices when making a recurrent broadcast. The redistribution trend is rather decreasing the professionals' control of the broadcast and increasing the uncertainty as to what will happen in the broadcast. Hence, automation is less likely to be of use in these situations.

Thus, on a general level, these trends are of a different kind. Automation and redistribution do not really go together hand in hand because automation is giving control to machines and formalizing the workflows, whereas redistribution implies that TV professionals lose control to other people, who are less trained and operate in unpredictable settings. It can create an opposition: redistribution pushes things out of the studio, allowing workers to work from home or remote locations, but automation pulls stuff to be going on in the studio, in a controlled environment. If we assume that the redistribution trend is the strongest, then the automation of studio work will be of less interest in the future.

5.3. *Implications for TV work*

Our findings confirm previous research on automation. For example, Autor (2015) suggests that people in general tend to overestimate the negative effects and neglect the positive effects of automation. Linden (2017) suggests that the introduction of automation to journalistic work does not result in job losses, as there is more to journalism than just writing stories, and only entry-level jobs might be in danger.

With the broader acceptance of TV production automation, we speculate that some jobs might become rudimentary, such as the job of a graphics producer during a live TV broadcast. However, the work will still exist in the form of preproduction graphics handling. In line with Bainbridge (1983), we see that automation has certain effects on skill requirements for jobs, but we do not find evidence that TV studio jobs are being de-skilled. Instead, they are rather being "re-skilled" (Nygren, 2014), as the producer in the automated studio needs fewer special skills to run the production but needs to be more polymathic.

Further, we speculate that the trends toward more versatile skills and employment of generally available Internet technologies will lower the barrier to new people and organizations which want to enter the TV industry. These trends are not new (Phillips et al., 2009). However, they have significantly accelerated during the pandemic. Along with I11, we speculate that legacy TV companies will start looking more for talented people outside of the industry who are familiar with Internet-based technologies and prove their creative potential via Youtube and other video-based social media sites. At the same time, the entry requirement for new employees will decrease as the required skills and expertise will be more related to Internet-based technologies that are already available to the general public.

The imposed adoption of general-purpose tools forced TV companies to reevaluate different aspects of TV work, such as broadcast quality and skill requirements. With such changes in place, TV companies could start taking advantage of services, tools and practices for video production and delivery commonly associated with video-based social media, such as Twitch and YouTube. For example, live streamers employ chat applications to connect with the audience and allow the viewers

to participate in the live video content production. These interactions between video producers and consumers and practices and social norms around them have been addressed in HCI and CSCW research (Abokhodair et al., 2015; Hamilton et al., 2014). Interaction with the live audience entails development and maintenance of audience management mechanisms which help broadcasters keeping track of the audience history, aggregating and visualizing various data, and categorizing the audience (Wohn & Freeman, 2020).

From the production perspective, live streamers are much leaner, as they seldom employ production teams and any specialized software and hardware (Wohn & Freeman, 2020). This practice of single-person inexpensive production might also be adopted by some TV companies as they start accepting lower quality and adopting automation.

5.4. *Limitations and further research*

This work aims to shed light on processes which happen inside the TV industry during the COVID-19 pandemic. While we were able to identify important and interesting trends from our rich material, there are some inherent limitations following our choice of method and the sample. We conducted an exploratory study based on interviews with representatives from different media organizations including world-renowned TV production companies. However, we do not know to what extent our findings and analytic generalizations are relevant to other legacy media organizations, including local TV channels. In the data gathering, we mostly focused on workflows inside TV studios and we show that some of them are being redistributed to the outside via, for example, interview kits that are being sent to show guests. How such changes were experienced by guests on TV shows and how the audiences have reacted to these changes in production quality is outside the scope of this paper. Further research is needed on *how* legacy TV companies adopt internet tools and practices into their workflows. Such studies should include observation of actual production practices. Furthermore it would be of interest to CSCW and HCI to study more closely the *interaction, coordination and planning practices* involved in automating live TV productions, including breakdown handling and establishment of backup systems and procedures.

6. Conclusion

In this paper, we looked at how regulations in the wake of the COVID-19 pandemic have influenced practices in live TV production. The transformations can be seen as temporary and imposed, and we focused on how they align with and accelerate existing changes. In particular, we discussed how the ecology of tools and practices in live TV production is being supplemented by Internet technologies and services. Some adaptations of the work practice require deep infrastructural change, such as adopting new protocols and hardware. Further, the integration of Internet technologies into live TV production will make available a number of innovations from this area. We discussed how a redistribution of work not only concerns the geographical location of people but also the adoption of new skills, new tools, and an adjusted conception of quality in TV production. Further, we discussed how the adoption of automated workflows can allow for streamlined production of content, but that it requires the work to be formalized. The notion of redistribution can contribute to conceptualizing the response to imposed and temporary conditions and how it aligns with ongoing, slower socio-technical changes.

Acknowledgments

The study is a part of the project "Better Video workflows via Real-Time Collaboration and AI-Techniques in TV and New Media," funded by the Research Council of Norway under Grant No.: 269790. This work was also partly supported by industry partners and the Research Council of Norway with funding to "MediaFutures: Research Centre for Responsible Media Technology and Innovation," through The Centres for Research-based Innovation

scheme, project No.: 309339. We would like to express our gratitude to Vizrt's Even Normann and Roger Saetereng. We would also like to thank our interviewees for their input.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributors

Pavel Okopnyi (Pavel.Okopnyi@uib.no) is a PhD Candidate focusing on social aspects of TV and Video production; he has a background in software engineering, Sociology, and HCI.

Frode Guribye (Frode.Guribye@uib.no) is a Professor of Information Science focusing on HCI and the social implications of ICT; his research spans different application areas such as technology enhanced learning, computing and mental health, video production and mobile journalism.

Valentina Caruso (valentinacaruso83@gmail.com) is a Senior UX Researcher with experience in software and web-based solutions; She holds a Ph.D. in Educational Sciences from the University of Fribourg (CH) and an MA in Technology and Language Teaching; Her interests include HCI and learning technologies.

Oskar Juhlin (oskarj@dsv.su.se) is a Professor at the Department of Computing and Systems Sciences at Stockholm University, and a guest professor at the MediaFutures research center at the University of Bergen.

Funding

This work was supported by the Norges Forskningsråd [269790].

ORCID

Pavel Okopnyi http://orcid.org/0000-0001-7034-2733
Frode Guribye http://orcid.org/0000-0002-3055-6515

References

Abokhodair, N., Yoo, D., & McDonald, D. W. (2015). Dissecting a social botnet: Growth, content and influence in Twitter. *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing* Vancouver, Canada (ACM), 839–851.

Andueza-López, B., & López-Plaza, M. (2020). The TV-production shift during the COVID-19 health crisis: How TV language changed as a state of alarm was enforced in Spain. *Tripodos*, 2(47), 161–172.

Arndt, S., Perkis, A., & Räty, V.-P. (2016). Opportunities of social media in TV broadcasting. *Proceedings of the 9th Nordic Conference on Human-Computer Interaction* Gothenburg, Sweden (ACM), 1–6. https://doi.org/10.1145/2971485.2995346

Arndt, S., Räty, V.-P., Nieuwenhuis, T., Keimel, C., Ibáñez, F., & Perkis, A. (2017). Enhancing use of social media in TV broadcasting. *Adjunct Publication of the 2017 ACM International Conference on Interactive Experiences for TV and Online Video* Hilversum, Netherlands (ACM), 51–56. https://doi.org/10.1145/3084289.3089923

Arntz, M., Gregory, T., & Zierahn, U. (2016). *The risk of automation for jobs in OECD countries: A comparative analysis* OECD Social, Employment and Migration Working Papers . https://doi.org/10.1787/5jlz9h56dvq7-en

Autor, D. H. (2015). Why are there still so many jobs? The history and future of workplace automation. *Journal of Economic Perspectives*, 29(3), 3–30. https://doi.org/10.1257/jep.29.3.3

Bainbridge, L. (1983). Ironies of automation. *Automatica*, 19(6), 775–779. https://doi.org/10.1016/0005-1098(83)90046-8

Bijker, W., & Law, J. (1992). Do technologies have trajectories. In W. E. Bijker & J. Law (Eds.), *Shaping technology/building society: Studies in sociotechnical change* (pp. 1–16). MIT Press.

Blaising, A., Kotturi, Y., & Kulkarni, C. (2019). Navigating uncertainty in the future of work: Information-seeking and critical events among online freelancers. *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* Glasgow, UK (ACM), 1–6. https://doi.org/10.1145/3290607.3312922

Bødker, S., & Klokmose, C. N. (2012). Dynamics in artifact ecologies. *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design* Copenhagen, Denmark (ACM), 448–457.
Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa
Buysschaert, C., Descampe, A., & Lorent, J.-B. (2020). Creating bandwidth-efficient workflows with JPEG XS and SMPTE ST 2110. *SMPTE Motion Imaging Journal*, 129(7), 33–40. https://doi.org/10.5594/JMI.2020.3001465
Casero-Ripolles, A. (2020). *Impact of COVID-19 on the media system. Communicative and democratic consequences of news consumption during the outbreak* (SSRN scholarly paper ID 3594133). Social Science Research Network. https://papers.ssrn.com/abstract=3594133
Castriota, S., Delmastro, M., & Tonin, M. (2020). *National or local? The demand for news in Italy during COVID-19* (SSRN scholarly paper ID 3733273). Social Science Research Network. https://papers.ssrn.com/abstract=3733273
Coche, R., & Lynn, B. J. (2020). Behind the scenes: COVID-19 consequences on broadcast sports production. *International Journal of Sport Communication*, 13(3), 484–493. https://doi.org/10.1123/ijsc.2020-0231
Courtois, C., & D'heer, E. (2012). Second screen applications and tablet users: Constellation, awareness, experience, and interest. *Proceedings of the 10th European Conference on Interactive TV and Video* Berlin, Germany (ACM), 153–156. https://doi.org/10.1145/2325616.2325646
Engström, A., Juhlin, O., Perry, M., & Broth, M. (2010). Temporal hybridity: Footage with instant replay in real time. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* Atlanta, GA, USA (ACM), 1495–1504.
Engström, A., Perry, M., & Juhlin, O. (2012). Amateur vision and recreational orientation: Creating live video together. *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work* Seattle, Washington, USA (ACM), 651–660.
Freilich, A., & Meyer, S. (1963). The "STEP" system a unique, low-cost TV automation system. *IEEE Transactions on Broadcasting*, BC-9(1), 16–25. https://doi.org/10.1109/TBC.1963.265906
Fröhlich, P., Baldauf, M., Meneweger, T., Tscheligi, M., De Ruyter, B., & Paternó, F. (2020). Everyday automation experience: A research agenda. *Personal and Ubiquitous Computing*, 24(6), 725–734. https://doi.org/10.1007/s00779-020-01450-y
Garfinkel, H. (1967). *Studies in ethnomethodology* (Prentice Hall).
Gerson, E. M., & Star, S. L. (1986). Analyzing due process in the workplace. *ACM Transactions on Information Systems*, 4(3), 257–270. https://doi.org/10.1145/214427.214431
Grudin, J. (1994). Computer-supported cooperative work: History and focus. *Computer*, 27(5), 19–26. https://doi.org/10.1109/2.291294
Guribye, F., & Nyre, L. (2017). The changing ecology of tools for live news reporting. *Journalism Practice*, 11(10), 1216–1230. https://doi.org/10.1080/17512786.2016.1259011
Hamilton, W. A., Garretson, O., & Kerne, A. (2014). Streaming on twitch: Fostering participatory communities of play within live mixed media. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* Toronto, Ontario, Canada (ACM), 1315–1324. https://doi.org/10.1145/2556288.2557048
Heinonen, K., & Strandvik, T. (2020). Reframing service innovation: COVID-19 as a catalyst for imposed service innovation. *Journal of Service Management*, 32(1), 101–112. https://doi.org/10.1108/JOSM-05-2020-0161
Higgins-Dobney, C. L., & Sussman, G. (2013). The growth of TV news, the demise of the journalism profession. *Media, Culture & Society*, 35(7), 847–863. https://doi.org/10.1177/0163443713495078
Hui, J., Cranshaw, J., Kotturi, Y., & Kulkarni, C. (2019). The future of work(places): Creating a sense of place for on-demand work. *Conference Companion Publication of the 2019 on Computer Supported Cooperative Work and Social Computing* Austin, TX, USA (ACM), 487–491. https://doi.org/10.1145/3311957.3359432
Hussein, N. (2015). *Broadcast Automation System: Newsroom Production* [Fi=AMK-opinnäytetyö|sv=YH-examensarbete|en=Bachelor's thesis|]. Metropolia Ammattikorkeakoulu. http://www.theseus.fi/handle/10024/92773
Juhlin, O., Engström, A., & Önnevall, E. (2014). Long tail TV revisited: From ordinary camera phone use to pro-am video production. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* Toronto, Ontario, Canada (ACM), 1325–1334. https://doi.org/10.1145/2556288.2557315
Juhlin, O., Engström, A., & Reponen, E. (2010). Mobile broadcasting: The whats and hows of live video as a social medium. *Proceedings of the 12th International Conference on Human Computer Interaction with Mobile Devices and Services* Lisbon, Portugal (ACM), 35–44.
Juhlin, O., Zoric, G., Engström, A., & Reponen, E. (2014). Video interaction: A research agenda. *Personal and Ubiquitous Computing*, 18(3), 685–692. http://dx.doi.org/10.1007/s00779-013-0705-8
Karis, D., Wildman, D., & Mané, A. (2016). Improving remote collaboration with video conferencing and video portals. *Human–Computer Interaction*, 31(1), 1–58. https://doi.org/10.1080/07370024.2014.921506
Koehne, B., Shih, P. C., & Olson, J. S. (2012). Remote and alone: Coping with being the remote member on the team. *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work* Seattle, Washington, USA (ACM), 1257–1266. https://doi.org/10.1145/2145204.2145393
Kostiukevych, I., Vermost, W., & Ferreira, P. (2019). Analyzing SMPTE ST 2110 streams using EBU's open-source software. *SMPTE Motion Imaging Journal*, 128(4), 1–6. https://doi.org/10.5594/JMI.2019.2899712

Ksentini, A., Naimi, M., & Gueroui, A. (2006). Toward an improvement of H.264 video transmission over IEEE 802.11e through a cross-layer architecture. *IEEE Communications Magazine*, 44(1), 107–114. https://doi.org/10.1109/MCOM.2006.1580940

Kumar, A., & Haneef, M. S. M. (2018). Is Mojo (En)De-skilling? *Journalism Practice*, 12(10), 1292–1310. https://doi.org/10.1080/17512786.2017.1389291

Lapierre, J., & Al-Habbal, M. (2018). Bridging the gap between software and SMPTE ST 2110 SMPTE 2018 Annual Technical Conference & Exhibition Los Angeles, CA, USA. , 2018 (SMPTE), 1–7. https://doi.org/10.5594/M001841

Linden, C.-G. (2017). Decades of automation in the newsroom. *Digital Journalism*, 5(2), 123–140. https://doi.org/10.1080/21670811.2016.1160791

Mlynář, J., González-Martínez, E., & Lalanne, D. (2018). Situated organization of video-mediated interaction: A review of ethnomethodological and conversation analytic studies. *Interacting with Computers*, 30(2), 73–84. https://doi.org/10.1093/iwc/iwx019

Musabirov, I., Bulygin, D., Okopny, P., & Konstantinova, K. (2018). Event-driven spectators' communication in massive esports online chats. *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems* Montreal, QC, Canada (ACM), LBW564.

Napoli, P. M. (2014). On automation in media industries: Integrating algorithmic media production into media industries scholarship. *Media Industries Journal*, 1(1 33–38). https://doi.org/10.3998/mij.15031809.0001.107

Nimako, S. G., & Ntim, B. A. (2013). Construct specification and misspecification within the application of push-pull-mooring theory of switching behaviour. *Journal of Business and Management Sciences*, 1(5), 83–95 http://pubs.sciepub.com/jbms/1/5/2/.

Nygren, G. (2014). Multiskilling in the newsroom–de-skilling or re-skilling of journalistic work? *The Journal of Media Innovations*, 1(2), 75–96. https://doi.org/10.5617/jmi.v1i2.876

Obrist, M., Bernhaupt, R., & Tscheligi, M. (2008). Interactive TV for the home: An ethnographic study on users' requirements and experiences. *International Journal of Human–Computer Interaction*, 24(2), 174–196. https://doi.org/10.1080/10447310701821541

Olson, G. M., & Olson, J. S. (2000). Distance matters. *Human–Computer Interaction*, 15(2–3), 139–178. https://doi.org/10.1207/S15327051HCI1523_4

Perry, M., Juhlin, O., Esbjörnsson, M., & Engström, A. (2009). Lean collaboration through video gestures: Co-ordinating the production of live televised sport. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* Boston, MA, USA (ACM), 2279–2288.

Phillips, A., Singer, J. B., Vlad, T., & Becker, L. B. (2009). Implications of technological change for journalists' tasks and skills. *Journal of Media Business Studies*, 6(1), 61–85. https://doi.org/10.1080/16522354.2009.11073479

Retelny, D., Bernstein, M. S., & Valentine, M. A. (2017). No workflow can ever be enough: How crowdsourcing workflows constrain complex work Proceedings of the ACM on Human-Computer Interaction 1 CSCW . , 1–23. https://doi.org/10.1145/3134724

Richards, G. (2010). Here is the news [automation broadcasting]. *Engineering Technology*, 5(9), 36–38 1750-9637 .

Satchell, C., & Dourish, P. (2009). Beyond the user: Use and non-use in HCI. *Proceedings of the 21st Annual Conference of the Australian Computer-Human Interaction Special Interest Group: Design: Open 24/7* Melbourne, Australia (ACM), 9–16.

Schmidt, K., & Bannon, L. (1992). Taking CSCW seriously. *Computer Supported Cooperative Work (CSCW)*, 1(1), 7–40. https://doi.org/10.1007/BF00752449

Stimson, R. J., & McCrea, R. (2004). A push – pull framework for modelling the relocation of retirees to a retirement village: The Australian experience. *Environment and Planning A*, 36(8), 1451–1470. https://doi.org/10.1068/a36206

Suchman, L. (1993). Do categories have politics? *Computer Supported Cooperative Work (CSCW)*, 2(3), 177–190. https://doi.org/10.1007/BF00749015

Tang, J. C., Zhao, C., Cao, X., & Inkpen, K. (2011). Your time zone or mine? A study of globally time zone-shifted collaboration. *Proceedings of the ACM 2011 Conference on Computer Supported Cooperative Work* Hangzhou, China (ACM), 235–244. https://doi.org/10.1145/1958824.1958860

Tharatipyakul, A., Li, J., & Cesar, P. (2020). Designing user interface for facilitating live editing in streaming. *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems* Honolulu, HI, USA (ACM), 1–8. https://doi.org/10.1145/3334480.3383037

Túñez-López, M., Vaz-Álvarez, M., & Fieiras-Ceide, C. (2020). Covid-19 and public service media: Impact of the pandemic on public television in Europe. *El Profesional de La Información* 29 5 , e290518. https://doi.org/10.3145/epi.2020.sep.18

Webb, A. M., Wang, C., Kerne, A., & Cesar, P. (2016). Distributed liveness: Understanding how new technologies transform performance experiences. *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing* San Francisco, California, USA (ACM), 432–437.

Weilenmann, A., Säljö, R., & Engström, A. (2014). Mobile video literacy: Negotiating the use of a new visual technology. *Personal and Ubiquitous Computing*, 18(3), 737–752. https://doi.org/10.1007/s00779-013-0703-x

Wohn, D. Y., & Freeman, G. (2020). Audience management practices of live streamers on twitch. *ACM International Conference on Interactive Media Experiences* Barcelona, Spain (ACM), 106–116. https://doi.org/10.1145/3391614.3393653

Yarosh, S., Bonsignore, E., McRoberts, S., & Peyton, T. (2016). YouthTube: Youth video authorship on YouTube and Vine. *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing* San Francisco, California, USA (ACM), 1423–1437. https://doi.org/10.1145/2818048.2819961