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Environmental Impact of Video Streaming From Users' Perspectives

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ABSTRACT

While the Internet has undeniably made a significant impact on human life, it comes with a drawback: its extensive energy consumption, leading to adverse consequences for the environment. The proliferation of video streaming services, which constitute the largest portion of Internet traffic, amplifies the environmental burden of the Internet. Recognising the critical role of users' video consumption behaviour to improve the situation, we employed a qualitative approach to explore users' perspectives on pollution caused by video streaming. Interviews were conducted with video streaming app users aged from 18 to 26 years old, originating from Germany, France, and the UK. Our aim was to uncover the relationship between users' awareness levels and their willingness to change behaviour regarding video content consumption. The research findings provide comprehensive insights into users' perceptions of video streaming impacts, and suggest potential avenues for future design and research aiming at promoting pro-environmental behaviour in video content consumption.

Keywords: Green UX, Internet pollution, Digital footprint, Video streaming, Sustainability, Pro-environmental behaviour, Human-centered design

INTRODUCTION

The environmental impact of the Internet is often perceived as minimal, and referred to as the "invisible polluter" (Oo, 2023). However, with the Internet becoming an indispensable part of human life, its frequent usage has caused an exponential increase in its environmental footprint. This trend is expected to continue growing in the next decades (Lindner, 2023). Facilitating Internet services requires energy resources across data centers, network infrastructures, and (in the operation of) users' devices, thereby consequently contributing to the carbon footprint levels (Stephens, 2021). Alongside this substantial energy demand of Internet services, we witness the phenomenal rise of video content notably through streaming applications, which now dominate Internet traffic (Marks, 2020). While technological research has focused on improving underlying technology to optimise energy use and computing efficiency, it's important to recognize that solely relying on technological aspects may not be adequate. Shifting the focal lens to Internet users, recent studies indicated that user behaviour on video streaming activities may also influence the carbon footprint intensity (Suski, 2020). Considering at global scale, small individual changes can offer huge impact to energy savings (Ejembi, 2014). Therefore, slight adjustments in video consumption habits,

such as choosing lower-quality options and limiting interactions that prompt automatic downloads, can substantially decrease the energy consumption (Batmunkh, 2022).

Realising the influence wielded by video consumers, this study aimed to explore users' perspectives on Internet pollution stemming from video streaming services. Our objective was to understand their perceptions on the topic and potentially inform future research aimed at promoting sustainable behaviours among video content consumers.

METHOD AND MATERIAL

We employed a semi-structured interview approach in this research to exploratively examine participants' diverse perspectives towards the topic. Eight participants aged between 18 and 26 years old were recruited from three European countries: Germany, France, and the United Kingdom with different occupational backgrounds. To qualify for the research, participants must have experience with video streaming services such as YouTube, TikTok, and Instagram, and spend at least one hour per day watching video content on these platforms.

To investigate the participants' perspectives, we began the interview with questions aimed at assessing their awareness toward the environment and their willingness to take sustainable actions. Next, we learned about their experience with video streaming services. Then, we presented participants with the collected information and statistics on how video streaming services negatively impact the environment. Following are the key points of our presentation:

- Internet consumption has an impact on the environment, it contributes to 5 % of the global electricity use; 3.7% of global carbon emissions, more than the aviation industry (Ferreboeuf, 2019); 416.2 TWh per year, more than the entire UK (Website carbon calculator, 2024)
- Environmental impact is caused by energy use for Data centres, Network Infrastructures, Devices (Stephens, 2021)
- On average, carbon emissions of one hour use: Youtube - 28 g CO2, Facebook - 47 g CO2, Instagram 63 g CO2, TikTok - 158 g CO2 (calculated using Social Carbon Footprint Calculator by comparethemarket); which means 60 min on TikTok every day for a year causes nearly 57.67 kg CO2. It is equal to driving a standard car for more than 144 miles (~233 km) (calculated using Carbon Footprint Calculator by Carbon Footprint)
- Over a year, with 10 millions monthly page views of tiktok.com/explore produces the amount of carbon that 5,045 trees absorb in a year; 10 millions monthly page views of youtube.com produces the amount of carbon that 4,218 trees absorb in a year (Website carbon calculator, 2024)
- In 2022, users worldwide spent approx. 23.3 hours using TikTok per month (Ceci, 2023); Users consume 1 billion hours of videos on YouTube everyday (Shewale, 2024).
- A chart illustrating the expansion of global Internet traffic from 1992 to 2022 reveals a significant increase. Over the span of 30 years, Internet traffic surged from 156GB to 150,000GB per second (WDR2021, 2021).

After the presentation, we explored participants' perspectives on the provided information, examining their perceptions and discussing strategies to promote pro-environmental behaviour in video streaming consumption.

KEY FINDINGS

Study Participants' General Environmental Awareness and Their Experience With Video Streaming

When asked about environmental sustainability, all participants demonstrated their awareness of the issue, with each of them rating its importance as 3 out of 5 and above on the rating scale. Moreover, 5 out of 8 participants showed a greater level of concern by rating it 4 out of 5. Aware that their daily activities may have harmful effects, most participants claimed to be environmentally conscious in their actions and everyday choices, e.g. by eating more sustainable food, buying second-hand clothes, and being mindful of electricity use, etc. Despite their awareness, some participants found it challenging to take further action as they prioritise convenience. Moreover, participants categorise certain activities as their daily routines that would be hard to modify. Few participants also expressed their belief that their individual voice and actions would be insignificant when viewed in the larger context.

Listing out the activities that are eco-unfriendly, most participants referred to physical activities such as driving, consuming food with unsustainable origins, using products with plastic packaging, wasting electricity. Few participants brought up their habits of using online services, linking it to electricity usage.

Looking more specifically into the video streaming segment of online activities, our participants reported spending an average of around 3.5 hours per day engaging with video content across various platforms such as TikTok, YouTube, Instagram, Facebook. Strikingly, 5 out of 8 participants indicated spending averagely more than 4 hours daily on video content, with some dedicating up to 10 hours a day on the weekend. P7 even admitted to leaving the YouTube videos played while asleep, and P1 reported that sometimes they watched videos on multiple devices simultaneously.

The findings regarding participants' general behaviours in ecological awareness and their experiences with video streaming platforms were utilised as background information for further exploration.

Users' Perception Toward the Presented Facts: The Environmental Impact of Video Streaming Services Was Rarely Recognized

When discussing the connection between video streaming and ecological consequences, none of the participants were aware of the environmental impact of watching videos. The only cause they could speculate about was the electricity consumption for devices. Our presentation gave participants a brief explanation on how Internet services contribute to environmental effects and estimated carbon footprint of four popular video streaming platforms (YouTube, TikTok, Instagram, Facebook). The revealed information came as

a surprise to all participants, as they had not previously reflected on this topic: *"I never gave it a thought that even a passive video consumption can have an impact on the environment. That's what most people do not think about."*, as shared by P2; similarly, P5 indicated *"this is the first time I've been exposed to facts and figures like this"*. The presentation not only broadened participants' perspectives but also motivated them to share the information with others (P4, P5, P7). For instance, P7, a science teacher, was enthusiastic about incorporating the Internet's environmental impact into their discussions with students.

Some participants noted that they tended to direct their attention towards tangible things such as petrol cars, plastics, and lighting, rather than intangible ones like online activities. Therefore, it was not surprising that none of them anticipated the carbon footprint figures to be as high as they had been shown in the presentation, as P1 commented *"I didn't know that this impact will be so expensive"*. They claimed that the presented figures changed their mind about video streaming activities. Four participants even considered it as the most ecologically damaging act they do in their daily lives. Especially, considering the widespread popularity of video content today, the ecological consequences were perceived as exponential, as P4 expressed her concern: *"these are daily activities that people would just do [...] the fact that it is so common means it's going to impact more and more."*

Different Levels of Impact by Different Services Raised Concerns Among Participants

The revelation that TikTok has the highest carbon footprint emitted from one hour of use compared to the other platforms sparked extensive discussion among the participants. When asked for their perceptions after receiving the information, P2 immediately highlighted TikTok's shockingly high carbon footprint as their initial reaction to the statistics. Likewise, with TikTok's impact in their minds, most participants referred to TikTok as a prime example in subsequent discussions. P7 conveyed her concern, stating *"it's scary that TikTok is the most popular and also is the worst one"*.

Participants were surprised to learn that despite offering similar types of content, the four example platforms exhibited varying levels of carbon emissions, *"I was surprised that TikTok is so much worse than YouTube, because they're both based on the same thing"*, as shared by P8. They frequently questioned the underlying technology of each platform and what made their carbon footprint different. *"I think in YouTube you pre-download the video and then you play it… Maybe that helps YouTube to produce less emissions"*, P2 wondered.

Remarkably, the fact pushed participants to the intention of switching to other platforms when they offer more ecological services, as indicated by P5: *"I'm thinking about my time on TikTok. I don't need to be for that long when I can probably get the same entertainment on YouTube. That is a bit of a different footprint."*

Relatable and Comparative Data Facilitate Understanding and Leave a Stronger Impact

During the presentation, we use relatable comparisons instead of focusing solely on carbon dioxide numbers to help participants better grasp the meaning behind the data. For example, we juxtaposed the Internet carbon footprint with that of the aviation sector, and watching TikTok footprint to driving a standard car. Also, we used websitecarbon.com (Website carbon Calculator, 2024) to calculate the number of trees needed to offset the carbon emissions resulting from access to TikTok and YouTube. Overall, the relatable comparisons helped participants in better understanding the data, as noted by P3, they would not realise the actual emissions from streaming services without a comparison with their daily activities.

Furthermore, these comparisons left a lasting impact on the participants that they notably emphasised these comparative figures during the post-information discussion. P5 expressed that the example of driving a car was shocking for her and prompted her to reflect on her own behaviour of watching TikTok. Meanwhile, P6 repeatedly referenced the example of the number of trees required to offset the environmental impact of visiting video streaming platforms: *"it's quite crazy because for one app you need that many trees to offset the carbon and there're so many different social media apps"*.

Participants, influenced by the impact of relative comparisons, suggested employing this technique to promote behaviour changes effectively. For example, P7 asked for information that would demonstrate the number of trees needed to offset their own TikTok usage, believing it would raise awareness and assist in gradually breaking the habit. Similarly, P3 suggested that comparing their usage to the distance driven by a car would help them become more mindful of their behaviour.

Acknowledgement Motivates Users

Being exposed to the figures of video streaming's impacts for the first time, most participants shared their intention to either cut down on the amount of time spent on video content or watch videos in a more sustainable manner. Some approaches for low-impact video consumption were discussed by participants such as reducing number of devices playing simultaneously (P1), switching to lower quality options (P2, P6), choosing more sustainable services (P2, P4, P5, P6, P8), and limiting background video playback (P8). A few participants admitted to a habit of mindlessly using their phones when they had nothing to do. However, they mentioned that the presented facts would make them more mindful when watching videos, as P4 indicated *"TikTok is such an eye opener for me, it's not like a necessity, I'll just do it because I'm just bored and have nothing to do. But I know I could find other ways to spend my time and it will actually help the environment"*.

Given such encouragement, participants discussed the critical need to spread awareness to foster behavioural changes in the community. They confirmed that the environmental topic was popularly discussed for decades but it's not common in the context of the Internet, and more specifically, video streaming activities. They proposed that exposing the facts similar to

what they saw in the presentation will encourage the society to take action. Remarkably, high frequency in broadcasting information was highlighted as the key in promoting awareness and encouraging pro-environmental actions, as P5 stated *"it's good having this one exposure here at this meeting. But maybe two weeks later, I might forget exactly how bad it is, but having a constant reminder would make me very more encouraged"*.

Regular Feedback Combined With Convenient Solutions

Besides spreading the knowledge, regular feedback of an individual's video content consumption was also brought up frequently as an approach to encourage behaviour changes. As P1, P5 and P6 suggested, a personal statistics, notification or any form of feedback shown to users informing them how much time was spent on the video streaming apps and the emitted carbon dioxide from that would potentially help them to realise their own impacts.

To motivate participants to take action, they suggested that solutions should be presented to them in a convenient manner. For instance, P8 proposed integrating immediate, actionable options into consumption feedback for users. An example of this would be a pop-up message while scrolling that asks users whether they want to lower video quality for ecological reasons. He believed that without such prompts, users might not naturally consider these options.

The Challenges and Realities to Modify Video Consuming Behaviour

While the majority of participants expressed a willingness to adopt more sustainable practices when consuming video content, many admitted that video-based platforms are already deeply ingrained in their daily lives, making it challenging to change their habits Despite understanding that reducing video quality can decrease its carbon footprint, some participants still showed reluctance. They justified this reluctance by either emphasising their prioritisation of high-quality entertainment (P1, P3, P4) or expressed their belief that any changes they make would have only a negligible impact (P3). Similarly, participants noted that the decision to switch to a more sustainable video platform will also rely on how attached they are to the current services.

Being prompted about how realistic it is that they would actually change their behaviour on a one-to-five scale, 6 participants confirmed a realistic level above 3, while P3 only gave a 1 out of 5 as they would change for their own productivity and environmental effect is not the primary drive, P6 rated a 2 out of 5 as they believed the adaptation wouldn't suffice to make any difference.

While participants' ratings are generally high, it's important to acknowledge the potential influence of cognitive bias, particularly considering their recent exposure to the information we presented. Furthermore, their limited information and lack of real-world experience may hinder their ability to accurately estimate their future actions, leading to unreliable self-assessments.

DISCUSSION

While the trend of users' attachment to video streaming services has only escalated in recent years, our study confirms that many techniques analysed

in prior studies for promoting behavioural changes towards sustainability remain applicable. Additionally, our study complements valuable insights to understand users' perceptions specifically in the context of modern video streaming.

Prior studies (Gan et al., 2021, Yadav et al., 2022) have frequently emphasised on the importance of acknowledging the environmental implications of products and users' actions to raise community's awareness. In the absence of relevant knowledge, the ecological problem becomes more significant (Bassi, 2019). However, recent research has noted that the concept of digital pollution is still relatively unfamiliar to the public (Grinstein, 2018). Similarly, our study findings revealed a deficiency in information concerning the environmental consequences of video streaming. Participants demonstrated a lack of awareness regarding the topic and expressed surprise upon learning about it. Just as everyone is typically more attentive to tangible daily products since their ecological impacts are widely educated, it is imperative to publicly and regularly communicate the environmental effects of digital services, with a specific emphasis on video streaming apps, to the public. This may prompt users to self-reflect on their behaviour and consider solutions to mitigate their own impact as revealed in the findings, as also highlighted by S. Yadav in his study (Yadav, 2022).

Consumption feedback has been long indicated as one of the prerequisite factors to promote users' awareness and assist them in habit alteration (Yu et al., 2014; Peña et al., 2023). Our study confirmed this statement in the context of video streaming. Participants frequently requested regular feedback on video consumption to stay informed about their current behaviours and make timely adjustments. Furthermore, to encourage immediate action, it is recommended to consider providing users with convenient, actionable ecological options during video streaming.

Early study indicated how the human mind makes sense of data by creating reliable ideas of reality from the given data (Grolemund, 2014). Our study demonstrated that users could readily comprehend the significance of provided figures when presented in relatable comparisons. This approach enabled them to relate the amount of carbon dioxide released to their daily activities, rather than assessing a numerical value that they might perceive as abstract and difficult to interpret as either high or low. Users expressed a need for such correlations while obtaining information to enhance awareness.

Consistent with prior research (Qin et al., 2022; Ye et al., 2022) emphasising the addictive behaviour of Internet users on video streaming platforms, our study participants also reported excessive usage of these services. Overall, their personal video consumption needs remain prioritised over environmental motivations. With such a strong attachment, implementing sustainable practices in video streaming will pose significant challenges for them, as they emphasised when assessing the feasibility of making actual behavioural changes.

LIMITATIONS AND FUTURE RESEARCH

While our study provides insights into users' perspectives, it is essential to acknowledge its limitations, which, in turn, present opportunities for future research. First of all, our study provided participants with insights into how video streaming impacts the environment in subtle ways, leading to the passive acquisition of information and potentially biassed perceptions. A comprehensive study can involve empowering users to actively control their own knowledge and information regarding the topic. This approach could potentially yield a broader range of perspectives from users. Besides, participants in our study were asked to self-assess their level of concern regarding environmental sustainability, as well as their realistic intentions to change behaviour. However, these self-assessments may be biassed, leading to either an overestimation or underestimation of the actual situation. To address this limitation, researchers could undertake studies employing varied research methods and metrics to evaluate environmental awareness and behavioural changes. This approach is designed to unveil a more reliable and comprehensive understanding of the relationship between these two aspects. Additionally, long-term studies could be conducted to observe users' behavioural changes regarding video content consumption once they are aware of the environmental impact. These studies may also investigate effective strategies to motivate users towards more sustainable video content consumption.

CONCLUSION

By employing a qualitative approach, our study yielded insightful findings regarding users' perceptions of the polluting impact of video streaming. Study participants generally exhibited an interest in environmental topics and asserted their consciousness regarding environmental actions. While they heavily engage with video streaming services, they do not perceive any correlation between watching videos and its environmental impact. This absence of recognition is like losing the key to unlock environmental awareness and, consequently, prompt ecological action among Internet users. Key avenues were identified in the study findings to potentially promote positive impact made by users. We determined that a detailed, specific look into each video content platform's ecological footprint, and personal video consumption feedback coupled with readily accessible actions, are essential to empower users to make sustainable choices. Despite the potential solutions, the deeply entrenched presence of video streaming in everyone's daily life may pose a significant challenge for future design and research aimed at motivating ecological action in video streaming. This study could complement existing research on video streaming pollution from users' perspectives. To delve deeper into the topic, future research may utilise diverse research methods to broaden users' insights. This could involve observing actual changes in users' behaviour over the long term and exploring users' perceptions through a more objective approach to minimise cognitive bias tendencies.

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