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Redesign and Nudging Strategies for Digital Wellbeing on YouTube

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Abstract

In the contemporary attention economy, tech companies adopt design patterns, e.g., content autoplay and infinite scroll, that exploit people' psychological vulnerabilities and manipulate users into spending time and attention on digital services. These "attention-capture damaging patterns" (ACDPs) often lead people to experience a lost sense of control and time over technology use and a later sense of regret. As a result, concerns about technology overuse and addiction have gained momentum, and researchers, public media, and some tech industries have started highlighting the need to design digital services that better align with people's digital wellbeing.

This thesis aims to develop and evaluate mitigation strategies and alternative design patterns for ACDPs that might positively impact people's digital wellbeing, rather than diminishing it. Specifically, the work is focused on the browser version of YouTube, targeting some ACDPs characterizing the aforementioned video streaming platform. Specifically, four steps have been followed.

First, an initial literature review on the digital wellbeing topic was conducted, with a particular focus on ACDPs.

Next, a set of mitigation strategies and alternative design pattern were designed to overcome the limits and drawbacks of three ACDPs found on YouTube, i.e., Infinite Scroll, Neverending Autoplay, and Disguised Ads and Recommendations. The mitigation strategies employed are nudges, e.g., highlighting when the user is scrolling infinitely by progressively changing the background color, or marking an ad with a with a colored border to distinguish it from other content. An example of alternative design patterns are redesigns, e.g., additional features altering the usual behavior of an existing interface.

The designed set of mitigation strategies and alternative design patterns were then integrated in the YouTube web interface, through the implementation of a Google Chrome extension called *TubeWizard*.

At last, the effectiveness of the implemented artifacts was evaluated through a twelve-day study involving 14 participants. This evaluation aimed to compare the impact of redesign and nudging strategies, and the findings revealed that both tactics encouraged intentional and mindful use of the platform.

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Sincerely,
Gabriele

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Chapter 1

Introduction

Within the current landscape of the attention economy [1, 2], technology companies strategically implement design elements such as content autoplay and infinite scroll. These design patterns exploit the psychological vulnerabilities inherent in individuals [3], coercing and manipulating users to invest their time and attention into digital services [4].

These manipulative strategies, termed as "attention-capture damaging patterns" (ACDPs) [5], frequently lead individuals to grapple with a diminished sense of control over their interactions with technology [6]. Users find themselves losing track of time while engaging with these digital interfaces, eventually experiencing regret and a pervasive sense of having surrendered autonomy [7, 8].

Consequently, mounting concerns surrounding the excessive use of technology [9] and its addictive potential [10] have garnered significant traction. Researchers [11], public media outlets [12, 13, 14], and a subset of the technology industry are now fervently advocating for the imperative need to create digital platforms and services that prioritize and cater to the enhancement of individuals' digital wellbeing, which can be defined as "the impact of digital technologies on what it means to live a life that is good for a human being in an information society" [15].

The issue of promoting people's digital wellbeing has traditionally been addressed by practitioners and researchers through the creation and application of Digital Self-Control Tools (DSCTs) [16], which are web browser extensions and mobile apps that let users track their usage patterns and set up self-monitoring devices through interventions like timers and lock-out mechanisms. Regretfully, several investigations have shown that modern DSCTs are not always successful, particularly over a prolonged period. In fact, the implemented intervention tactics are rather rudimentary and arbitrarily prevent the user from interacting, such as by prohibiting the use of an app for the rest of the day. Moreover, they mostly depend on users' self-monitoring techniques and skills [17]. Focusing on the internal mechanisms used by digital services, like YouTube's autoplay, that are likely to contribute to

excessive technology usage and undesirable behaviors, is a viable (and presumably more effective) alternative to timers and lock-out procedures. Redesigning such systems with the goal of eliminating troublesome elements from an application or website without sacrificing its usefulness is the fundamental concept underlying such an approach. With a few noteworthy exceptions [8, 18], the field of DSCTs that target internal systems has not received much attention. Additionally, there is currently a lack of clarity on how to persuade important stakeholders to reconsider their design processes and goals in order to better support users' digital health and restrict these manipulative mechanisms from the start.

1.1 Goal

The primary objective of this thesis is to delve into the creation and assessment of mitigation strategies and alternative design patterns intended for ACDPs. These strategies and patterns are aimed at fostering a positive impact on individuals' digital wellbeing, steering away from actions that could potentially diminish it. More specifically, this research is centered around the browser version of YouTube. Its main focus lies in addressing certain ACDPs that typify the previously mentioned video streaming platform.

In particular, the project involved a systematic execution comprising four sequential steps.

Firstly, a comprehensive review of existing literature pertinent to digital wellbeing was undertaken, focusing extensively on ACDPs.

Subsequently, a collection of mitigation strategies and alternative design patterns were formulated to address the limitations and shortcomings identified in three prevalent ACDPs on YouTube: Infinite Scroll, Neverending Autoplay, and Disguised Ads and Recommendations. These strategies encompassed the use of nudges, such as dynamically altering the background color to indicate continuous scrolling, and implementing visual cues like colored borders to distinguish advertisements. Additionally, alternative design patterns involved interface redesigns with the incorporation of supplementary features to modify the conventional user experience.

The devised set of mitigation strategies and alternative design patterns were seamlessly integrated into the YouTube web interface through the development and implementation of a Google Chrome extension known as *TubeWizard*.

Finally, an evaluation was conducted to assess the efficacy of the implemented artifacts, employing a twelve-day study with the participation of 14 individuals. This assessment aimed to compare the effects of redesign strategies versus nudging techniques. The findings of this evaluation revealed that both approaches effectively encouraged intentional and mindful utilization of the platform.

1.2 Structure of the thesis

This thesis is structured into several chapters, described as follows:

- **Chapter 2 - Literature Review on Digital Wellbeing and ACDPs**: the first step involved conducting an extensive literature review on the topic of digital wellbeing, with a specific focus on Attention-Capture Damaging Patterns (ACDPs). A comprehensive examination of existing research, theories, and studies related to digital addiction, user behavior, and the impact of ACDPs on individuals was performed. Key findings and theories that shaped the research direction were highlighted.

- **Chapter 3 - Design of Mitigation Strategies and Alternative Design Patterns**: in this phase, a set of innovative solutions to address the limitations and drawbacks of three YouTube website's ACDPs was developed. The research entailed a creative process to devise strategies for combating digital addiction. Indeed, the use of "nudges", such as different background color and borders, was proposed to alert users when ACDPs were in operation. These tools served to encourage users to reflect on their online behavior. Additionally, the concept of alternative design patterns was introduced as a promising avenue for exploration. Redesigns involving the implementation of buttons to disable scrolling, autoplay, and ads offered a different user experience that could promote healthier online habits.

- **Chapter 4 - Integration of Mitigation Strategies and Alternative Design Patterns**: the next step involved practically implementing the designed strategies and patterns directly into the YouTube web interface. The technical aspects of the integration process were detailed. This phase encompassed the development of a Google Chrome browser extension named *TubeWizard* to apply these alterations. The general architecture along with the main functions of the extension were discussed.

- **Chapter 5 - Evaluation of Implemented Artifacts**: in this stage, the effectiveness of the nudging and redesign strategies that were implemented was assessed through a field study with 14 participants. The evaluation methodology and criteria used to investigate the objective of the experiment were outlined. Various data collection methods, such as questionnaires and user metrics, were employed to gather information on changes in participants behavior. The focus was on comparative analysis, as mentioned, to determine the effectiveness of the aforementioned strategies. The findings, including any statistically significant outcomes and trends, were presented along with a discussion about needs in the digital wellbeing area and limitations of the work.

- **Chapter 6 - Conclusions**: in this last chapter, final judgments are made about both implemented strategies' efficacy, highlighting possible future directions.

Chapter 2

Literature Review on Digital Wellbeing and ACDPs

With the rise of digital services like social media and video streaming platforms, technology has become an essential part of our everyday lives. These services benefit society and individuals for a variety of reasons, including entertainment and educational opportunities as well as social interaction. However, there is rising worry about the detrimental effects these services may have on our digital wellbeing — a cutting-edge psychological concept that outlines the difficulties associated with maintaining a positive relationship with technology in the modern infosphere [15].

2.1 Digital wellbeing

Studies about the detrimental effects of excessive technology usage are increasing substantially [19]. Particularly, smartphones have been reported to be a source of distraction [20], and overusing them can have negative effects on social interaction and mental health [21, 22]. Additionally, cellphones provide as a gateway for a number of mobile applications that, for example, can lead to compulsive social media checking [23]. In response, HCI researchers began to focus more on the area of deliberate "non-use" of technology [24, 25, 26], and the phrase "smartphone addiction" has grown in popularity in both the literature and the general public [27]. Studies have shown that excessive digital media use can lead to negative outcomes such as decreased well-being, increased anxiety, and addiction-like behaviors [28, 29]. Even Google and Apple recently unveiled new tools for tracking, comprehending, and limiting technology use in their operating systems with the aim of encouraging a more mindful use of the smartphone. Currently, a wide variety of mobile apps can be used as tools to change users' behavior with smartphones. The phrase "digital wellbeing" was used by Google in particular to sum up its commitment: "our goal

is to enhance people's wellbeing through supporting an intentional relationship with technology" [30].

In brief, according to multiple studies, users in particular frequently succumb to compulsive behaviors like mindlessly scrolling through social media newsfeeds [31] or watching more videos or movies than they meant [8, 32] since they are generally unable to resist the temptations of media use [33].

Users frequently link issues with digital wellbeing to a lack of self-control [34], but mounting research evidence indicates that tech corporations intentionally target these issues rather than chance [8, 35]. Particularly, a novel category of "dark patterns", known as Attention-Capture Damaging Patterns (ACDPs) [5], is currently employed to characterize malevolent patterns such as the potential for endless interface scrolling or the widespread use of "guilty pleasure" recommendations on social media and video streaming services.

2.2 Attention Capture Damaging Patterns

Tech companies are focusing on attention capture [36], a valuable resource in the digital age [1], to exploit users' sense of agency [7, 8] and control over technology use [6]. These attention capture mechanisms are known as "dark patterns", and are used by designers to manipulate users into actions against their best interests [37]. But because it's troublesome to associate "dark" with harm, in order to speak more inclusively, terms like "damaging patterns" [38] and "deceptive design (patterns)" [39] were introduced to describe these harmful designs. Harry Brignull introduced the concept in 2010 [40] and uses a Twitter hashtag campaign to highlight examples.

The idea of damaging patterns has increased awareness among designers [37], researchers [11], and media [12, 13, 14], leading to regulatory hearings [41, 42] and regulations [43] against damaging patterns, with others under consideration [44].

Narayanan et al. highlight that damaging patterns, such as Sneak into Basket [37, 40] and Privacy Zuckering [37, 40], allow designers to extract money, data, and attention from users [45]. Researchers [37, 46] and practitioners [40] have focused on these patterns, examining their prevalence and impact on financial and privacy harm [47]. Progress has been made in identifying manipulative design patterns.

The attentional harms of damaging patterns have been largely overlooked, with only one of Brignull's 12 patterns focusing on interfaces tricking users into spending time against their interests [8]. However, a systematic overview of designs leading to attentional harm across domains, including social media [48], is lacking, leading to calls for design community identification.

2.2.1 ACDPs: definition and criteria

A. Monge Roffarello et al. define an attention capture damaging pattern (ACDP) as "a recurring pattern in digital interfaces that a designer uses to exploit psychological vulnerabilities and capture attention, often leading the user to lose track of their goals, lose their sense of time and control, and later feel regret" [5].

ACDPs aim to maximize continuous usage, daily visits, and interactions by creating a trap for users to revisit and engage with similar rewarding content [3, 8]. Five criteria can be used to characterize and identify ACDPs, reported in Table 2.1, with the first two related to the mechanism exploited by ACDPs and the others addressing the impacts that ACDPs may have on users' digital wellbeing.

C1 - Exploit Psychological Vulnerabilities. Attention-capture damaging patterns exploit psychological biases to induce actions against users' best interests, such as excessive app usage. These designs exploit user biases, causing people to make decisions they may not have considered [3]. ACDPs often use a variable schedule of rewards [49], which triggers dopamine release. Social networks' newsfeeds exploit psychological vulnerabilities similar to gambling addictions by allowing users to check in advance for posts that may be rewarding or not. This uncertainty encourages continuous use [50], leading to reward depletion [9, 51], where users scroll through existing content while waiting for new ones to appear. This can lead to addiction and addiction.

C2 - Automate the User Experience. Attention-capture damaging patterns can automate user experiences, leading to meaningless normative dissociation experiences. This phenomenon occurs when individuals temporarily disconnect from physical and emotional experiences, losing self-awareness and reflection. This can lead to reduced intentional choice and can manifest in various mental states like daydreaming or absorbed in a movie [52]. ACDPs often remove the need for autonomous decision-making to induce meaningless normative dissociation, preventing users from engaging in meaningful decision-making [53].

C3 - Lose Track of Goals for Use. Attention capture patterns can cause users to lose track of their goals by demanding attention and introducing frequent distractions [54, 55]. These patterns can attract [56] or divert [49] attention, leading users to take actions aligned with stakeholder goals rather than their own [18]. Frequent distractions can decrease users' productivity [6, 8].

C4 - Lost Sense of Time and Control. Attention-capture-damaging patterns can cause a loss of control and time, negatively impacting users' sense of agency [8]. User agency, or self-agency, is defined as a person's perception of initiating

Criteria	Category	Description
C1	Mechanism	Exploit known psychological biases and heuristics
C2	Mechanism	Automate the entire user experience
C3	Impact	Lead users to lose track of their goals
C4	Impact	Lead to a lost sense of time and control
C5	Impact	Lead to a sense of regret about the time spent on a digital service

Table 2.1: Set of 5 criteria characterizing attention capture damaging patterns.

actions [57]. ACDPs can reduce user autonomy of choice by adopting coercive and deceptive strategies, affecting their self-perception [3, 58, 59].

C5 - Sense of Regret. Exposure to attention-capturing damaging patterns, such as using digital services or specific interactions, is often linked to later regret. The regret theory [60] suggests that regret is a counterfactual feeling that the past might have unfolded differently if a different decision had been made. Being exposed to attention-captured digital patterns (ACDPs) increases the likelihood of using digital services at times when users would not have otherwise [6], leading to regret. Websites and mobile apps that users spend the most time on are also regrettable [3].

2.2.2 A typology of ACDPs

The next thing A. Monge Roffarello et al. did was use the research they had read to create a typology of ACDPs. While taxonomy and typology are frequently used synonymously [61], they specifically choose typology to highlight the fact that those patterns are "ideal types", that is, types that reflect characteristics that are shared by the majority of examples in the literature.

Table 2.2 summarizes the whole typology of 11 attention capture damaging patterns. The remaining portion of this section goes over those 11 designs, providing a definition, application context, and examples for each.

P1 - Infinite Scroll. Infinite Scroll is a design pattern where content automatically loads at the bottom of a mobile app or website as the user scrolls down. This design can be seen as a "harmful feature" [62] or "anti-pattern" [63], promoting endless usage sessions [49]. It is related to operant conditioning theory [64] and variable reward technique [46], as it creates the illusion that new interesting content will flow forever. However, the quality of the next visualized items cannot be predicted. Infinite Scroll is an example of how attention capture can automate interactions, reducing the individual's physical and mental effort to spend more time on the platform.

Context and Examples. Infinite Scroll is most problematic in bite-size content, such as on social networks like Facebook, Instagram and Twitter.

P2 - Casino Pull-to-refresh. Casino Pull-to-refresh is an interaction technique where users can manually reload the system's status by swiping down on a mobile app. This can result in an animated reload of the page, which may or may not reveal new content. This design pattern can be considered attention capture damaging, offering a variable reward to users and potentially leading to a compulsive usage pattern, where users repeatedly refresh the app to wait for new content to appear [9, 65].

Context and Examples. Such an interaction approach is characteristic of touch-based interfaces and targets social network users on smartphones. Pull-to-refresh procedures such to those used in casinos are particularly problematic when the underlying material is complex and not so predictable. In this sense, the reward's quantity (whether or not it exists) and quality (how much the new social media post(s) gratify the user) are both variable.

P3 - Neverending Autoplay. Neverending autoplay is a design style where new videos play endlessly without any user input. Like other patterns, autoplay can be advantageous in some situations — such as when used to watch music videos on YouTube while working — and harmful in others, such as when it is abused to garner attention at the expense of the user's interests [8]. Particular issues with people's digital welfare occur when autoplay is "neverending" and difficult to turn off. Autoplay was categorized as an ACDP that undermines users' sense of agency since it does not require autonomous decision-making [3].

Context and Examples. Nevereding Autoplay is a pattern prevalent in social networks and video streaming platforms. In platforms like Facebook and Instagram, videos start automatically as soon as they appear on the screen, while users' stories flow on their own or through a simple tap. Autoplay is often active by default, making it difficult for users to deactivate it [62]. YouTube, on the other hand, attracts users by automatically starting a new video [66] when the previous one ends. Users can easily disable or enable autoplay functionality through a slider embedded in the video player. This pattern doesn't provide users a stopping cue or pause for reflection. Neverending Autoplay on social networks is used to attract users and maximize the amount of content they interact with, while YouTube uses autoplayed videos as step-by-step recommendations, enforcing more extended viewing sessions [67].

P4 - Guilty Pleasure Recommendations. Guilty Pleasure Recommendations are personalized suggestions that target users' individual consumer frailty to keep them on a platform. These recommendations offer pleasurable content but leave

users feeling guilty afterward. Digital services often use recommender systems to propose new content based on past interactions or similar user preferences. However, misalignment between the platform's goals and the user's goals can make recommendations an attention-capturing damaging pattern, trapping users in the system and keeping their attention [49, 59]. These clickbait suggestions [8, 55] increase the platform's utility without benefiting the user. Unfortunately, these recommendations cannot be easily personalized or disabled without third-party tools, and they are particularly harmful to people lacking self-control and self-esteem [49, 68].

Context and Examples. Social media platforms like Facebook and video streaming platforms like YouTube are effected by Guilty Pleasure Recommendations. Both platforms frequently provide clickbait suggestions [8, 66], which makes users more compulsive over time [67]. To draw attention and enhance video watch-through [49], YouTube offers a ton of tailored recommendations. On the other hand, social networks propose a variety of content kinds, including friends [49], games [55], and hot topics [69]. Long-term use of this can result in increasing compulsiveness.

P5 - Disguised Ads and Recommendations. This dark pattern in mobile apps and web pages has been studied in the past, and it was classified as interface interference [37]. By referring to the practice of blending concealed adverts with camouflaged advice as regular content, A. Monge Roffarello et al. [5] broaden the definition of the Disguised Ads pattern.

Context and Examples. Disguised Ads and Recommendations are strategically used to lengthen users' visits to social networks like Facebook and Twitter. These online services add fresh, attention-grabbing information that looks like posts from friends to users' newsfeeds, tricking them into clicking more frequently [53]. Advertising [53], sponsored content [70], and suggested posts [55] — often written by people you don't follow — can all be injections.

P6 - Recapture Notifications. Recapture Notifications are notifications consciously delivered to users who have abandoned a digital service for some period of time. As notifications proliferate to catch their attention, consumers may find their productivity suffers [71] and their stress levels rise as a result [72]. Tools for digital self-control allow users to filter or disable notifications [17]. Recapture notifications need to be controlled or avoided because they might be a cover for unlocking devices and using them for additional app or website activity [65].

Context and Examples. Recapture notifications are a common element in instant messaging, video streaming, and social media. On social networks, they share information about other people's activities, exhibiting a cross-cutting design pattern [55].

P7 - Playing by Appointment. Playing by Appointment is a usage pattern that is intended to draw attention and promote frequent use of a digital service. It encourages users to use it at predetermined times rather than at their discretion [73] in order to keep their chance of winning something.

Context and Examples. Playing by Appointment characterizes some social media games [73], such as Farmville and some Pokémon games, where users earn rewards when accessing those games at specific times. This pattern can also be found in social notworks, e.g., Snapchat and BeReal.

P8 - Grinding. Grinding is a pattern where users repeatedly go through a process to unlock an achievement [74]. This pattern makes digital services time and attention consuming by encouraging engagement and promising future achievements [75].

Context and Examples. Grinding is typical in multiplayer games, but can also be found in social networks, specifically in social media games [37].

P9 - Attentional Roach Motel. The Attentional Roach Motel pattern is a design pattern that makes it more difficult to cancel or log out of an attention-capture digital service than it is to create and access the service; it can be used to access account settings more difficultly [62].

Context and Examples. Social media is where this phenomenon is most troubling and noticeable. For instance, signing out from Facebook is a very difficult operation considering the logout button's limited visibility [62]. Moreover, the difficult procedure of deactivating or deleting a Facebook account was described by Bhoot et al. [76].

P10 - Time Fog. By concealing the amount of time spent watching a video, the pattern seeks to reduce user feedback on the use of digital services while increasing the likelihood of longer usage sessions [67].

Context and Examples. Time Fog can be found in video streaming services and mobile games that launch in full-screen mode by concealing the smartphone's clock.

P11 - Fake Social Notifications. Fake social notifications are dishonest practices when digital services communicate about another person's social actions about content that the user has never interacted with or send messages on the user's behalf [77]. These methods make users erroneously think that messages come from actual people and are frequently used to persuade them to open and begin utilizing a particular digital service [18, 69].

Context and Examples. Games hosted on social networks frequently use fake social notifications. Games like Candy Crush Saga and Farmville may pretend

Pattern name	**Description**	**Main context(s) of use**
P1 - Infinite Scroll	As the user scrolls down a page, more content automatically and continuously loads at the bottom.	Social media (e.g., Facebook, Instagram, and Twitter).
P2 - Casino Pull-to-refresh	When the user swipes down on their smartphone, there is an animated reload of the page that may or may not reveal new appealing content.	Social media on smartphones.
P3 - Neverending Autoplay	A new video is automatically played when the current one finishes. There is never a point for the user to stop and reflect, and the option to turn off autoplay is hidden or non-existent.	Social media and video streaming platforms, e.g., YouTube.
P4 - Guilty Pleasure Recommendations	Personalized suggestions that prey on individual consumer frailty to target user's guilty pleasures and increase use time.	Social media and video streaming platforms, e.g., YouTube.
P5 - Disguised Ads and Recommendations	Advertisements and recommendations, e.g., posts and sponsored pages, that are disguised as normal content into social networks' newsfeeds.	Social media.
P6 - Recapture Notifications	Notifications that are deliberately sent to recapture users' attention and have them start a new usage session, e.g., notifications with recommended content or notifications about content the user has never interacted with.	Social media, video streaming platforms, and messaging applications.
P7 - Playing by Appointment	Users are forced to to use a digital service at specific times as defined by the service, otherwise the user may loose points and achievements.	Video games (mostly on social networks) and social media in general.
P8 - Grinding	Users are forced to repeat the same process several times to unlock an achievement, e.g., a new level in a video game or a badge on a social network.	Video games and social media.
P9 - Attentional Roach Motel	Registering to and accessing attention-capture digital services is easy, while operations like logout or canceling an account are painfully difficult.	Social media, e.g., Facebook.
P10 - Time Fog	A pattern through which designers reduce users' awareness of time spent, e.g., by hiding the smartphone's clock.	Video streaming platforms, e.g., Netflix.
P11 - Fake Social Notifications	The platform sends messages pretending to be another user or social notifications about some content the user has never interacted with.	Video games (mostly on social networks) and social media in general.

Table 2.2: Typology of 11 attention capture damaging patterns.

to be another player by communicating actions they never carried out [73]. This pattern is also common on social networks such as Twitter and Telegram.

Chapter 3

Design of Mitigation Strategies and Alternative Design Patterns

In the previous chapter, a thorough evaluation of existing literature on digital wellbeing was conducted, with a heavy emphasis on ACDPs. These patterns, which are used to optimize user interactions and time spent, also enhance the revenue from advertisements. Yet they impair people's capacity to value their time [78] and cause them to feel guilty afterwards [5]. Nevertheless, in spite of this evidence, scholars and professionals have conventionally embraced general strategies to assist individuals in exercising digital self-control. Digital Self-Control Tools (DSCTs) [16, 79], in particular, primarily concentrate on preventing the user from engaging with a distracting app or website altogether, such as by enabling users to set their own usage time limits, which frequently results in high attrition rates [80].

3.1 DSCTs, nudging strategies and commitment interfaces

Human Computer Interaction (HCI) researchers and practitioners have created Digital Self-Control Tools (DSCTs) [16] in response to the long-standing interest in technology addiction and overuse. By using self-monitoring approaches [79], these tools — external mobile apps or browser extensions — help users control distracting apps or websites. Users can establish interventions like usage timers and blockers and keep track of how much time they spend using their devices with these tools, such as productivity dashboards. DSCTs, however, have limitations since they concentrate on preventing any user contact with a website or app without

focusing on the internal attention-capture strategies used by the same service [8]. Due to high attrition rates, this strategy may restrict interaction options without addressing the underlying issues, rendering DSCTs useless over the long term [17].

To address threats to digital wellness without overburdening end users, alternatives to conventional DSCTs are emerging. Social media use can become less addictive through the use of digital nudges [81], which are described as alterations in the system's structure that are employed to influence user behavior without imposing bans or limiting their interaction options [82]. These prompts can lead to deliberate choices and purposeful usage sessions, which can pave the way for systemic improvements that will last for a long time. Redesigning user interfaces is another possible solution to reduce the negative effects ACDPs. Instrumental use is prioritized by tools like Adaptable Commitment Interfaces [78], which also encourage users' sense of agency and control. Users of the YouTube substitute SwitchTube [78] can switch between an explore mode with a reduced sense of agency and a focus mode with concealed recommended videos.

3.2 Comparing redesign and nudging strategies

In this thesis, I investigated the implementation of two new and different tactics that encourage people to exercise digital self-control by focusing on particular attention-capture patterns without interfering with the user's engagement with the digital service:

- a **redesign strategy**, through which the interface is combined with additional user-actionable features altering its usual behavior to mitigate the disruptive effects of ACDPs and encourage users' autonomy and control;

- a **nudging strategy**, through which color alterations highlighted the presence of ACDPs in the interface to increase users' awareness and trigger conscious decisions without imposing bans or limiting their interaction options.

Though analogous approaches start appearing in the field of digital wellbeing research [78, 81], it remains to be seen how they would affect the usage of various platforms and, more specifically, which consumers would choose.

To answer these questions, I first selected the YouTube website as the primary focus of the work because it has historically been linked to issues related to digital wellbeing and discussed in studies on that topic [8, 78]. Indeed, despite it has incorporated tools like the "Take a break" option to encourage digital wellbeing and decrease overuse in order to solve this, users still view YouTube as a diversion, which could lead to remorse for excessive use. YouTube usage can have a negative effect on a user's choices, objectives, and sense of agency.

Consequently, it was important to discover which ACDPs were present on YouTube. Monge Roffarello and De Russis [83] discovered that it contains five ACDPs:

- **Infinite Scroll**: new content is automatically loaded at the end of the page;
- **Neverending Autoplay**: a new video is automatically played when the previous one ends;
- **Guilty-Pleasure Recommendations**: viral suggestions to increase use time;
- **Disguised Ads and Recommendations**: ads and suggestions disguised as regular content;
- **Recapture Notifications**: notifications to make users start a new session.

This research didn't focus on the fifth damaging pattern, Recapture Notifications, as this pattern has a way greater impact on smartphones rather than browsers. Furthermore, considering how YouTube suggests new contents, meaning that they all are personalized suggestions based on previously watched videos and therefore challenging to distinguish from "real" new contents, Guilty-Pleasure Recommendations could be collapsed into the Infinite Scroll damaging pattern.

Then, I held some prototyping sessions targeting those three specific ACDPs adopted by the aforementioned video-streaming platform to come up with design ideas for both strategies. All of the solutions primarily drew inspiration from the best practices in digital well-being advocated by Google [30] and Apple [84]. However, it was the paper by Chaudhary et al. [67], in particular the chapter "Design considerations for digital well-being", that truly resonated with me as I read it, especially in the context of the Neverending Autoplay feature.

Before discussing the various prototypes developed for the redesign and nudging strategies, I would like to emphasize that the proposed interventions for the mentioned ACDPs were designed to be applied only in specific sections of YouTube. Specifically, Infinite Scroll and Disguised Ads were intended for use on the homepage, while Neverending Autoplay was intended for use on video pages. Last note before we proceed, I'd like to clarify that the prototyped redesigned solutions were not real "redesigns" that result in a change in the appearance of the interface; rather, they consisted of added features, such as buttons, that introduce specific functions altering the usual behavior of YouTube. Nevertheless, for the sake of brevity, I will refer to these strategies as "redesigns". However, I would like to preface that, due to some challenges encountered during the development of the Chrome extension (which will be mentioned in the subsequent chapter), the solutions that were actually implemented are *R2 - User Interaction* and *N1 - Color*. So, the following pages will feature the various prototypes I have created.

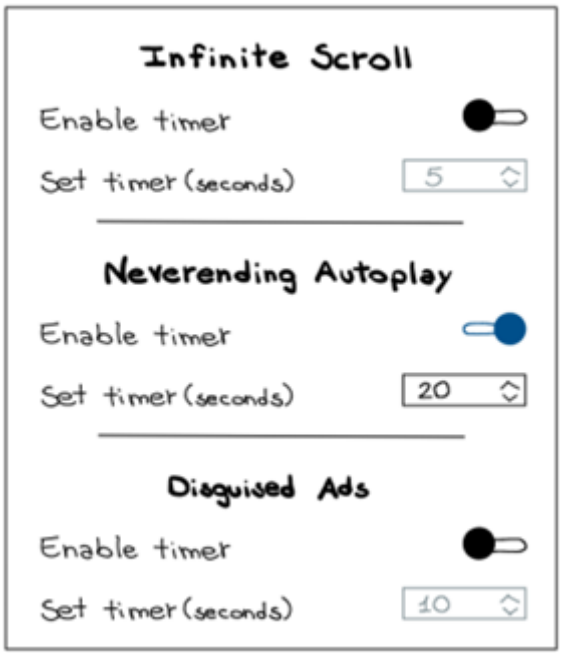

Figure 3.1: Time Dilation dashboard.

3.2.1 Redesign strategies

By redesign, in this context, we mean additional features altering the usual behavior of YouTube to place an emphasis on practical use and encourage users' autonomy and control. There are two general strategies that came up to my mind, later discussed with descriptions and pictures:

- **R1 - Time Dilation**: delay the pattern from activating for a longer period of time;
- **R2 - User Interaction**: users decide whether to activate/hide the pattern.

R1 - Time Dilation. The Time Dilation strategy allows users to set timers to slow down the loading process of new contents, next videos, and ads. It could be implemented as shown in Figure 3.1. There are three sections, one for each pattern, with a timer to be set. When a section is disabled, it isn't possible to set the associated timer. Timers are numeric forms, up to 20 seconds with a 1 second step. In this example, the Infinite Scroll timer is not enabled, so YouTube will be acting as always instead of adding an additional delay before loading new contents at the bottom of the page. The Neverending Autoplay timer will prevent another video from playback until 20 seconds have passed, instead of YouTube's default 8 seconds. Last, the Disguised Ads timer is also disabled and so ads will be

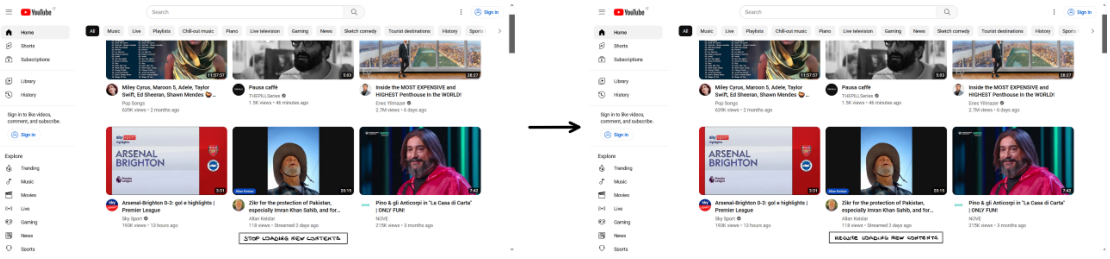

Figure 3.2: Before and after clicking the button that enables/disables the loading of new contents.

loading in the homepage as any other content; adding a delay to ads would make ads appear later than videos.

R2 - User Interaction. With this strategy users have to press a button or an icon to keep going or pause YouTube's features. Specifically, there are different approaches of this mitigation according to a specific pattern, described below each with an example.

Infinite Scroll. Users have to click on a button saying "Stop loading new contents" placed at the bottom of the page in order to block the subsequent loading of new videos at the bottom of the page. A new button indicating "Resume loading new contents" will be shown in place of the former after new contents loading has been disabled. By pressing it, new contents will be loaded again as usual. A visual representation can be found in Figure 3.2.

Neverending Autoplay. When a video ends, YouTube starts a countdown time of a few seconds in which users can choose whether to start the next suggested video ("Play now" button) or to abort ("Cancel" button) the automatic playback. In the former case, the recommended video begin automatically. In the latter one, the next video will not show up again, but many other videos will be displayed. The idea is to insert a new option in the video player ending screen, i.e., a button saying "Make a pause", with which users can stop the countdown, so they can have more time to think whether to watch a new video or make a pause. Please consult figure 3.3 for a visual depiction.

Disguised Ads and Recommendations. Each ad thumbnail displayed in the homepage will be flagged with a cross icon near its top-right corner. By hovering with the mouse the ad card, a button saying "Not interested" will be shown and, if clicked, will stop ads suggestions in the homepage for 30 minutes. A message displaying a countdown timer will replace the ad's thumbnail, together with an "Undo" option that, if clicked, will allow users to come back if they want, making ads reappear in the homepage. Refer to Figure 3.4 for a visual representation.

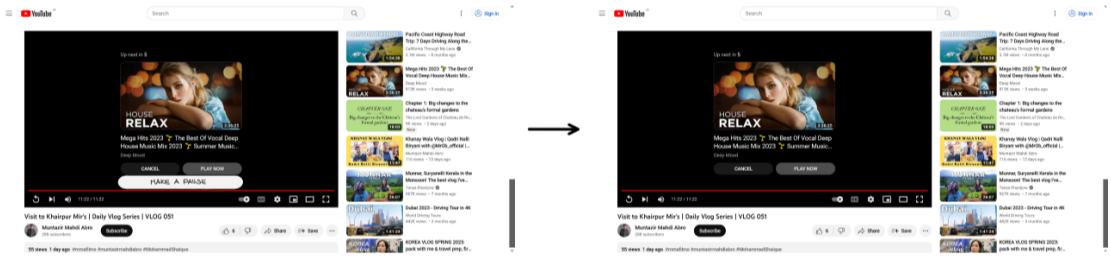

Figure 3.3: Before and after pressing on the "Make a pause" button.

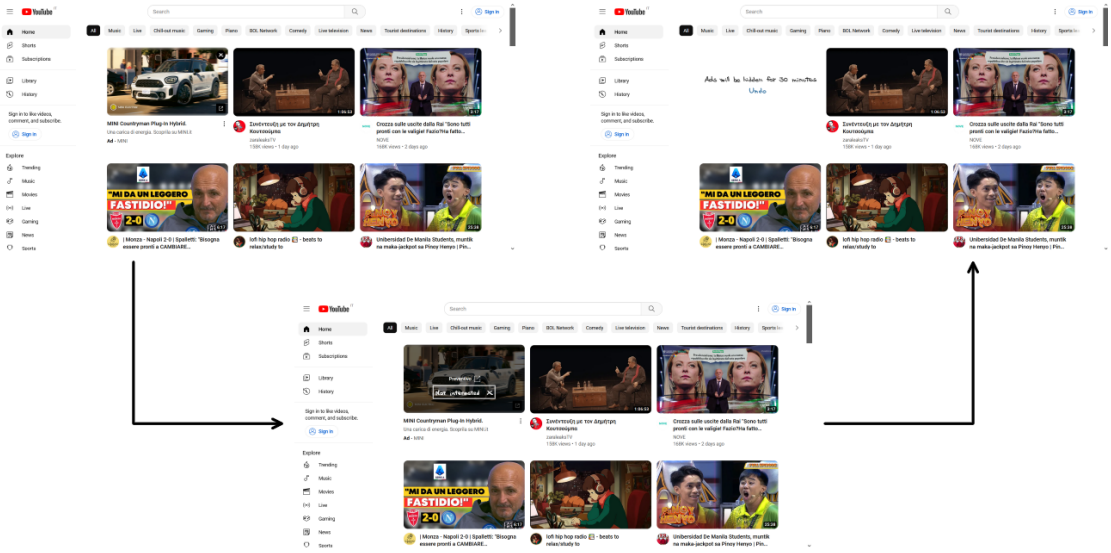

Figure 3.4: Before, when hovering and after clicking the "Not interested" button.

3.2.2 Nudging strategies

With nudging we mean alterations in the system's structure that are employed to influence user behavior without imposing bans or limiting their interaction options. As for redesign, there are two possible strategies, later discussed with descriptions and pictures:

- **N1 - Color**: properties of some items in the page change when certain actions/events happen;
- **N2 - Fade**: the same as colors, but with a greyscale fade effect.

N1 - Color. Changes in color draw attention to the ACDPs that are present in the interface. This nudging strategy is implemented in different ways depending on the damaging pattern.

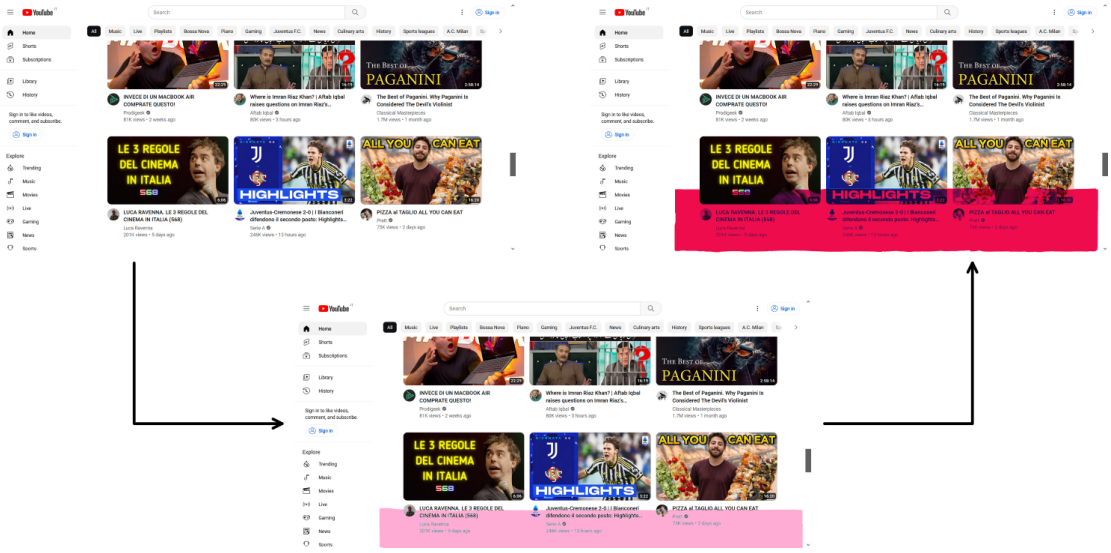

Figure 3.5: The color transition scrolling down contents in the homepage.

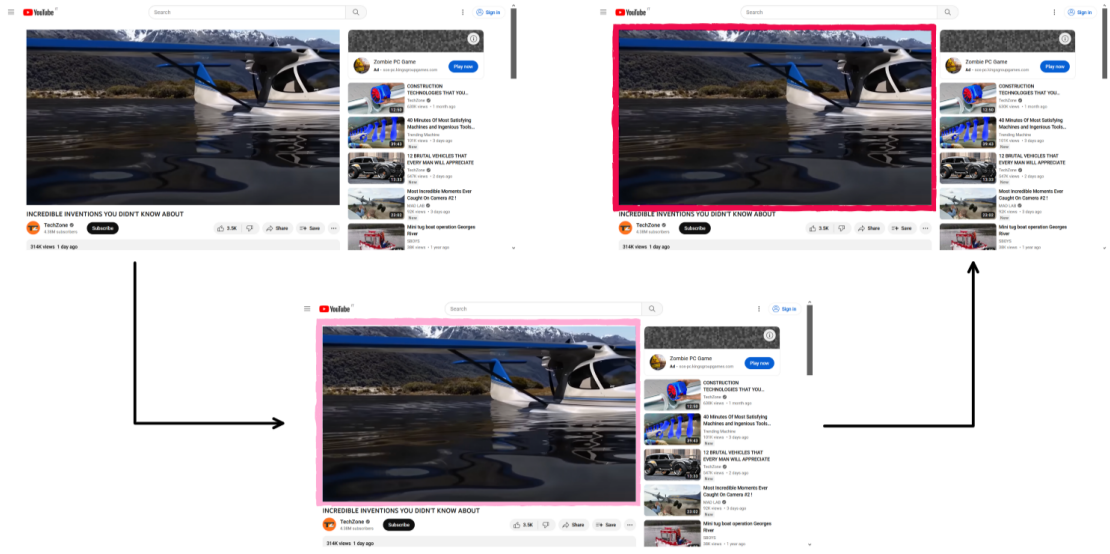

Figure 3.6: The color shifts when watching new videos with autoplay activated.

Infinite Scroll. The further users scroll down the suggestions page, the bottom background color gradually turns red with a color gradient. Please consult figure 3.5 for a visual depiction.

Neverending Autoplay. The more videos are seen with autoplay enabled, the more video's background turns red with a gradient fashion. Refer to Figure 3.6 for a visual representation.

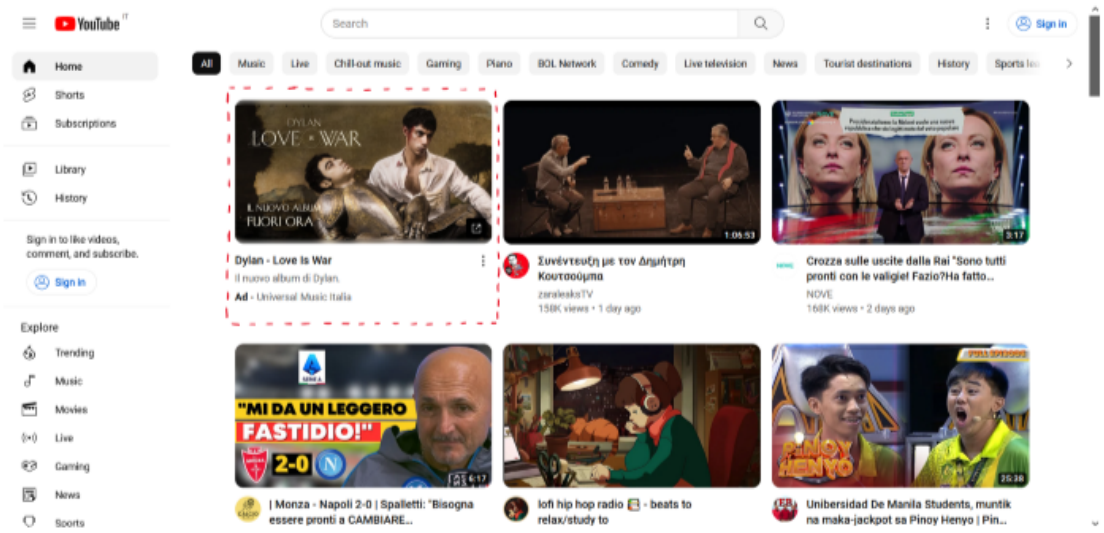

Figure 3.7: A red dashed border surrounding an ad in the homepage.

Disguised Ads and Recommendations. There is a red dashed border surrounding the ad card. A visual representation can be found in Figure 3.7.

N2 - Fade. This strategy is very similar to the one using colors, but with a greyscale fading effect highlighting the presence of ACDPs in the interface. Just like the color nudge, depending on the pattern, multiple approaches are taken while implementing this tactic.

Infinite Scroll. The further users scroll down the suggestions page, the latest loaded contents will gradually fade away (see figure 3.8).

Neverending Autoplay. A radial gray gradient will gradually appear as long as users continue to watch videos with activated autoplay (see Figure 3.9).

Disguised Ads and Recommendations. A fading effect similar to the one used for Infinite Scroll will partially hid ads (see Figure 3.10).

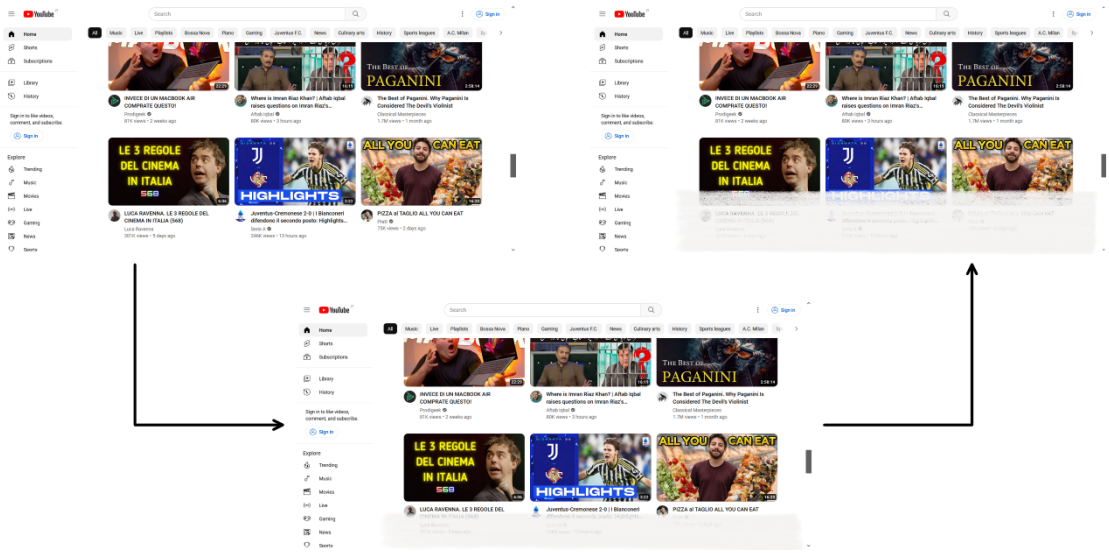

Figure 3.8: The fade transition scrolling down contents in the homepage.

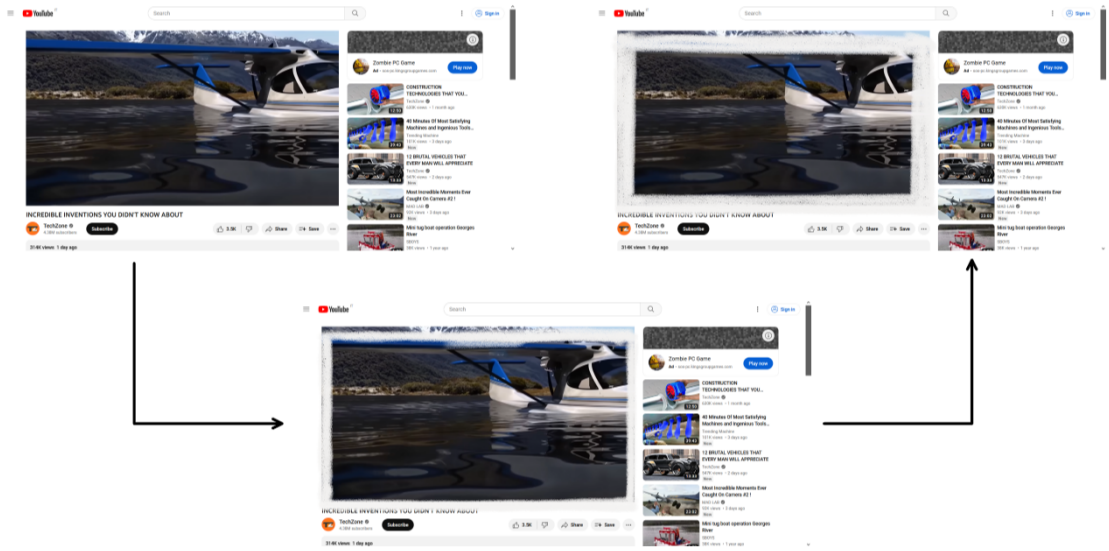

Figure 3.9: The fade growth when watching new videos with autoplay activated.

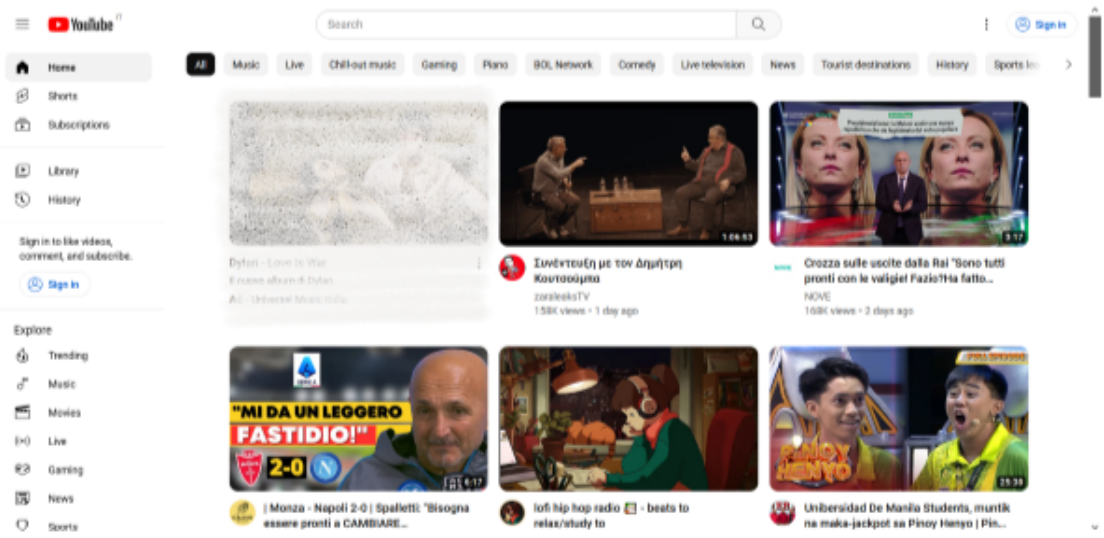

Figure 3.10: A faded ad in the homepage.

Chapter 4

Integration of Mitigation Strategies and Alternative Design Patterns

In this chapter the technical parts of the integration process of the newly designed elements and nudges are thoroughly discussed. An extension called *TubeWizard* was developed by exploiting the Chrome extension API[1] and Firebase[2].

4.1 Extension overview

Chrome extensions improve the browsing experience by introducing new features and capabilities to the Chrome browser, such as:

- productivity aids;
- enhancement of web page content;
- information gathering.

These are only a few of the many functions that extensions can do.

The same web technologies used to build web applications are also used to write extensions:

- as a content markup language, HTML[3] is employed;

[1]https://developer.chrome.com/docs/extensions/reference/, last visited on Sep 22, 2023.

[2]https://firebase.google.com/, last visited on Sep 22, 2023.

[3]https://web.dev/learn/html/, last visited on Sep 22, 2023.

- styles are created with CSS[4];
- JavaScript[5] is used for reasoning and scripting;
- you can use almost any functionality that is offered by a regular web page by using web platform APIs[6].

All of the JavaScript APIs that the browser offers can be used by extensions. Because they have access to the Chrome APIs, extensions are more potent than web apps. A few instances of what extensions can achieve are as follows:

- alter a website's operation or behavior;
- permit users to gather and arrange information from many websites;
- enhance Chrome DevTools.

Depending on the functionality offered, different files are included under different extensions. Some of the most commonly used files include the ones listed below:

- **the manifest**: the only file that needs have a precise file name is the manifest for the extension, which is `manifest.json`. Additionally, the root directory of the extension must contain it. The manifest lists which files should execute in the background and on the page, defines resources, declares rights, and stores vital metadata;
- **the service worker**: events from the browser are handled and heard by the extension service worker. There are many other kinds of events, including changing pages, deleting bookmarks, and shutting tabs. Although it is capable of using all Chrome APIs, it is not able to interact directly with web page content, unlike content scrips;
- **content scripts**: JavaScript is executed by content scripts within the framework of a web page. They have the ability to read and alter the DOM of the pages they inject themselves into. Only a portion of the Chrome APIs can be directly accessed by Content Scripts; but this limit can be overwhelmed by communicating with the extension service worker;
- **the popup and other pages**: a popup, an options page, and other HTML pages are examples of the numerous HTML files that can be included in an extension. Chrome APIs are available to all of these pages.

[4]https://web.dev/learn/css/, last visited on Sep 22, 2023.

[5]https://developer.mozilla.org/en-US/docs/Learn/JavaScript, last visited on Sep 22, 2023.

[6]https://developer.mozilla.org/en-US/docs/Web/API, last visited on Sep 22, 2023.

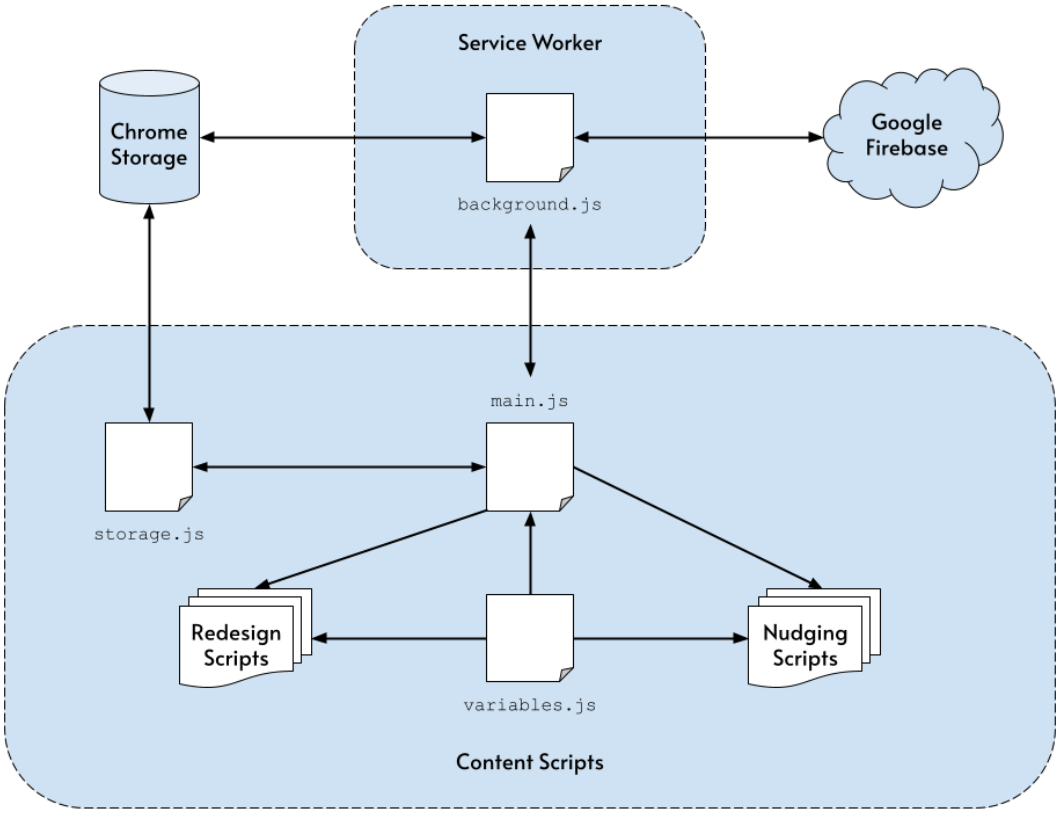

Figure 4.1: Architecture of the extension.

After this general introduction to extensions in Google Chrome, let's now delve into a detailed discussion of the extension. Figure 4.1 represents the extension's architecture, showing how the different files communicate among one another.

The followings are the main files and folders that make up *TubeWizard*.

`manifest.json` file. The configuration file for the Chrome extension that must be located in the project's root. It gives the browser access to an extension blueprint that contains crucial details like:

- the extension's name, an explanation of what it does, its current version number, and the appropriate icon sets;
- the credentials and permissions for the Chrome API that the extension requires;
- the scripts used in the content, the HTML file used in the pop-up window, the extension service worker files, etc.

`background.js` file. The extension service worker, i.e., an event-based script that the browser executes in the background. It is employed as the extension's event manager as well as a data processor and task coordinator, watching for and responding to events. The service worker has access to all extension APIs, but it is unable to utilize the DOM APIs offered by the global Window object of a document. Additionally, because it operates independently, it is unable to directly alter the content of a web page. The designated section contains more insights.

`content-scripts` folder. Extensions inject code into host pages, i.e., the websites that a content script communicates with defined with the help of matching patterns, by using the JavaScript files inside this folder. Those files enable the extension to communicate with and alter browser pages. It is thanks to those scripts that was possible to integrate the design and nudging strategies to YouTube (see the dedicated section for further details). While running in a separate JavaScript environment (the extension's isolated world), Content Scripts have access to the same DOM tree as the host page. Additionally, they have a restricted amount of access to Chrome APIs.

`storage.js` file. It contains two functions, `getExtStorage(callback)` and `setExtStorage(newExtStorage, callback)`, enabling the extension to interact with its local storage. The former one retrieves data from the local storage and passes it to a callback function for further use. The latter stores new data in the local storage by merging the new data with existing data, saving it, and then invoking a callback function with the updated storage data. To sum up, these functions facilitate the management and persistence of extension settings and state information.

`variables.js` file. It defines a string called `activeMode` that is used to activate either redesign or nudging strategies depending on its value. It also declares an object called `MARKUP`, which contains structured data for interacting with and manipulating elements on YouTube web pages. In fact, it contains css selector for classes, ids, and names of new HTML elements to facilitate actions and modifications within the Chrome Extension, distinguishing them based on the type of page, i.e., home or video page, they are needed for.

`icons` folder. It contains some icons in various sizes representing the extension. A 128x128 icon is required at all times because it is used both during installation and by the Chrome Web Store. A 48x48 icon is used in the extensions management page. A 16x16 icon is also specified to serve as the favicon for the extension's pages. Chrome will attempt to use the best size when appropriate. PNG is often the best

format for icons because it supports transparency the best. They may, however, be in any Blink-compatible raster format, such as BMP, GIF, ICO, and JPEG.

`css` folder. It contains files for styling design and nudging elements.

4.2 Service Worker

As told before, the primary event handler of *TubeWizard* is the service worker. The following is a list of the functions it handles.

- **`init()`**: it is used for proper extension configuration as it initializes the extension by calling two important functions to set up connections and updates: `listenToConnectionPorts()` and `keepServiceWorkerAlive()`.
- **`listenToConnectionPorts()`**: its primary purpose is to handle connections between the extension and different tabs in a web browser. When a connection is made, it logs details about the port and associates it with a specific tab. It sets up event listeners to handle incoming messages and disconnections. Additionally, it establishes a timer, which triggers the port disconnection after a few minutes thanks to two utility functions.
- **`keepServiceWorkerAlive()`**: it ensures the service worker remains active on specific web pages, i.e. YouTube, It is a vital function because Chrome terminates a service worker when a single request takes more than 5 minutes to process, a `fetch()` response takes more than 30 seconds to arrive, or after 30 seconds of inactivity.
- **`listenToTabsUpdate()`**: it manages events related to browser tabs by listening for new, removed and updated tabs. When a tab is removed, it clears any associated history data from local storage. When a tab is updated, i.e., either the tab active status or the URL change, it communicates these changes to the tabs.

Moreover, in addition to what has already been mentioned, it also deals with saving and retrieving data from the local storage structure on the client.

As a final point, this is also where the initialization, connection, and management of the tracked user data occur. For further details, the topic is covered in more depth in the Firebase dedicated section.

4.3 Content Scripts

As previously mentioned, content scripts are files that run in the context of web pages. By using the standard Document Object Model (DOM), they are able to

read details of the web pages the browser visits, make changes to them, and pass information to their parent extension.

All content scripts are controlled by the functions within the `main.js` file, of which I will list the most important ones along with a brief explanation:

- **`openConnectionPortWithExtensionBackground()`**: it establishes a connection between the extension's background service worker and a web page. This connection allows the communication between the web page and the extension. It also sets up event listeners for handling disconnections and incoming messages.

- **`restoreSavedStatus(tabInfo, callback)`**: this function is called after each YouTube's tab update. It examines the current web page's URL using regular expressions to categorize it as a homepage, video page, or other. Based on the page type, it calls specific functions to resume, clean, or adjust redesign or nudging strategies, depending on whether we are entering or leaving a home/video page.

- **`onAfterRedirectToHomePage(tabInfo, callback)`**: its purpose is to manage actions that occur after redirecting to the homepage of YouTube. In addition to performing cleanup after visiting a video page, it waits for the content grid, i.e., the container element of the video cards, in the homepage's DOM to load, retrying if it's not found. Depending on the extension's active mode, i.e. redesign or nudging, it restores specific features related to Infinite Scrolling and Disguised Ads handling.

- **`onAfterRedirectToVideoPage(tabInfo, callback)`**: it is used to handle actions after accessing YouTube's video pages. After cleaning up what's left from the homepage, it restores the Neverending Autoplay features depending on the current active mode.

- **`cleanAfterHomePage(tabInfo)`**: it removes all redesign/nudging elements, e.g., the "Stop loading new contents" button or the red color fade at the bottom of the page, that were previously introduced when leaving the YouTube's homepage.

- **`cleanAfterVideoPage(tabInfo)`**: the same as the previous function, but for stopping or removing event listeners or elements added in a video page and not useful anymore in the homepage of YouTube.

After this description of the utilities in the `main.js` file, we will now look at an high-level overview of the chosen artifacts, without delving too deeply into the details, featuring images of the final product and highlighting any differences from what was previously prototyped.

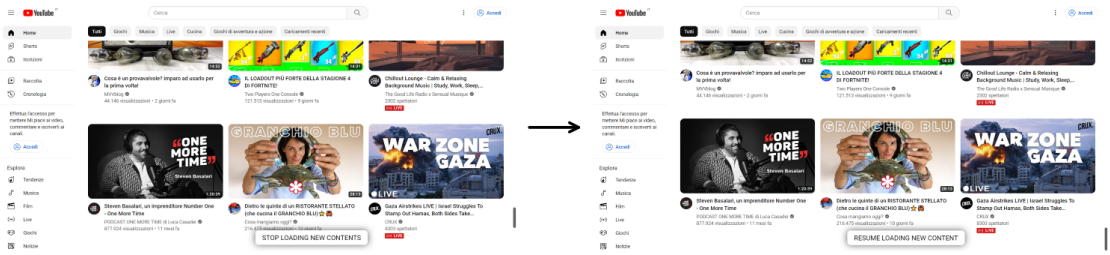

Figure 4.2: Before and after clicking the button that enables/disables the loading of new contents. Please note that the right scroll cursor reached the very end of the page as there are no more videos below.

I want to emphasize, as mentioned in the previous chapter, that there were specific reasons behind selecting the *R2 - User Interaction* redesign strategy. After attempting to implement the features of the *R1 - Time Dilation* strategy, I encountered certain obstacles. Firstly, it was impossible to capture some YouTube events, such as the loading of new content at the bottom of the page, and subsequently relaunch them with a delay. Secondly, it's impossible to modify events embedded within YouTube's internal scripts, like the countdown timer at the end of a video, to extend or shorten it. These are just a few of the reasons that led me to opt for the R2 strategy. As for the nudges, both *N1 - Color* and *N2 - Fade* solutions were virtually equivalent, and my choice of N1 was purely for aesthetic reasons.

4.3.1 Redesign - User Interaction

Infinite Scroll. For the Infinite Scroll, everything is nearly identical to what was created during the prototyping phase. By clicking the button that appears at the bottom of the page, all the content from the current position down to the end of the page will be hidden, preventing the loading of new content. Clicking the button again, of course, reveals all the previously hidden content, reactivating the mechanism that allows the loading of new videos. Refer to Figure 4.2 for a visual representation.

Neverending Autoplay. As for the Neverending Autoplay, there have been some minor changes. The "Make a pause" button no longer stops the countdown timer that starts at the end of a video; instead, it simply disables autoplay by turning off the related toggle button and displays the message "...zzz..." in place of the suggested video, indicating that a pause is in progress. By doing so, a new video will not start automatically. A visual representation can be found in Figure 4.3.

Figure 4.3: Before and after pressing on the "Make a pause" button.

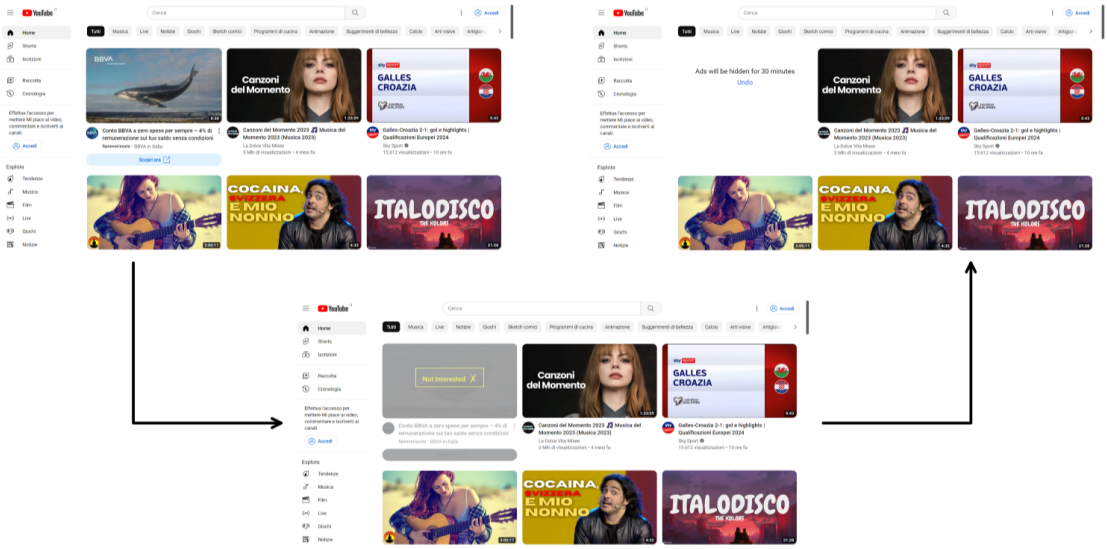

Figure 4.4: Before, when hovering and after clicking the "Not interested" button.

Disguised Ads and Recommendations. Regarding Disguised Ads and Recommendation, only a minor change has been made, which is the removal of the "x" icon on the ad cards. The rest is essentially identical to what was prototyped, so when hovering over the card, a "Not interested" button will appear, which can be clicked to hide all ads on the homepage for the next 30 minutes. After this period, they will become visible again. The countdown timer is visible in place of the ad cards. Additionally, at any time, it is possible to restore their visibility by clicking on the "Undo" option located below the countdown timer. Please consult figure 4.4 for a visual depiction.

4.3.2 Nudging - Color

Infinite Scroll. Talking about the Infinite Scroll nudge, it is exactly identical to what was prototyped in the design phase. So, as long as the user scrolls videos on

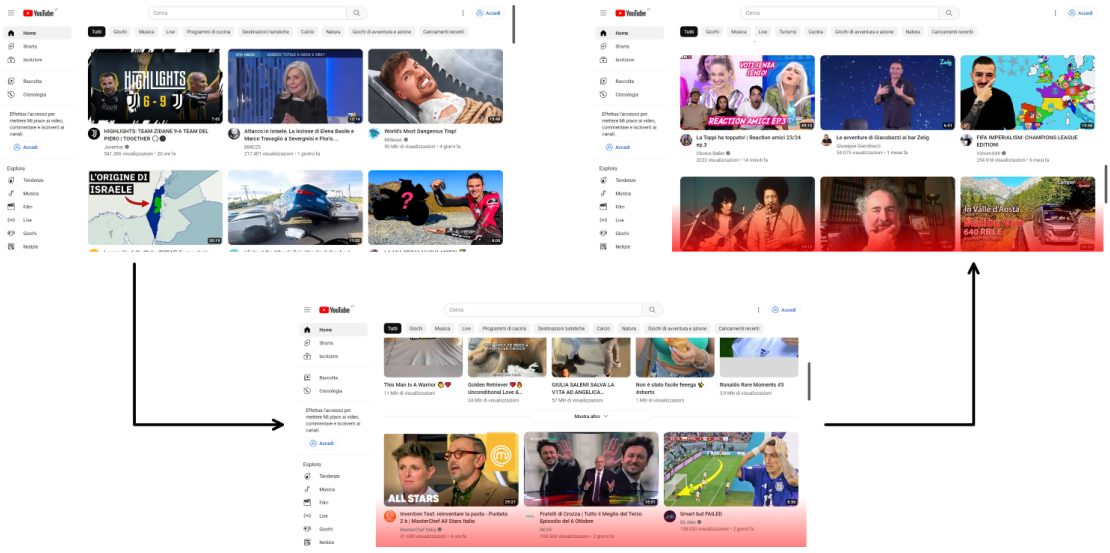

Figure 4.5: The color transition scrolling down contents in the homepage.

the home page, the bottom background color progressively turns red in a gradient fashion. Refer to Figure 4.5 for a visual representation of the nudge.

Neverending Autoplay. As per the scroll, the Neverending Autoplay nudge is an exact replica of the prototyped one. As long as the autoplay is enabled and users start watching a new video after the previous one ended, the background color of the video becomes a little bit more red. A visual representation of the nudge can be found in Figure 4.6.

Disguised Ads and Recommendations. At last, even the Disguised Ads and Recommendations nudge is equal to what I had prototyped, with each ad in the homepage surrounded by a red dashed border. Every time new contents are loaded in the homepage, a new scan to search for ads is triggered. Please consult Figure 4.7 for a visual depiction of the nudge.

4.4 Firebase

A collection of backend cloud computing services and application development platforms are offered by Google through Firebase. It supports a wide range of apps, including Android, iOS, JavaScript, Node.js, Java, Unity, PHP, and C++, and hosts databases, services, authentication, and integration.

After having created a Firebase project and registered the app, installed the SDK and initialized Firebase, I accessed it in *TubeWizard* by exploiting one of

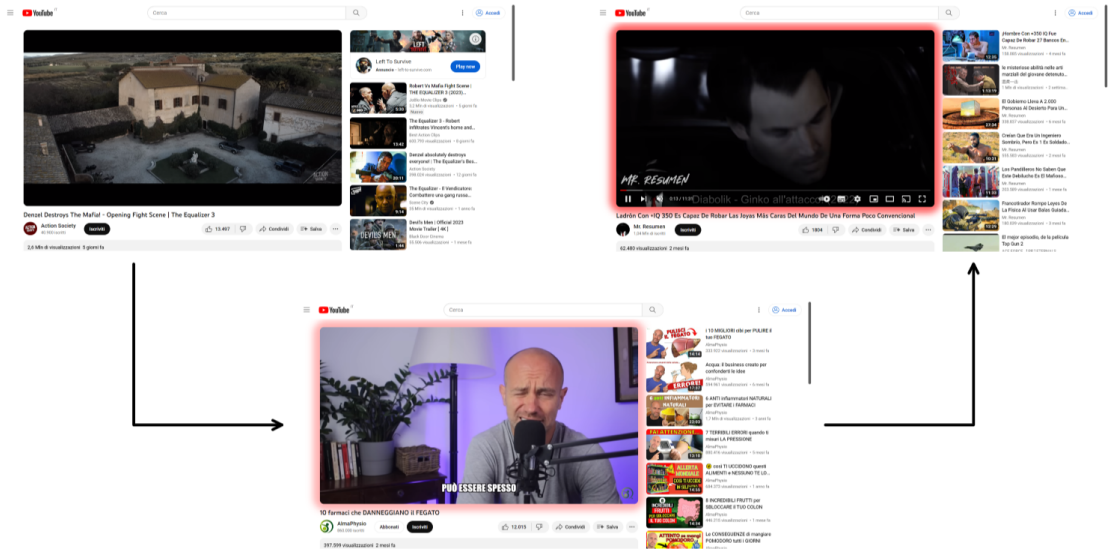

Figure 4.6: The color shifts when watching new videos with autoplay activated.

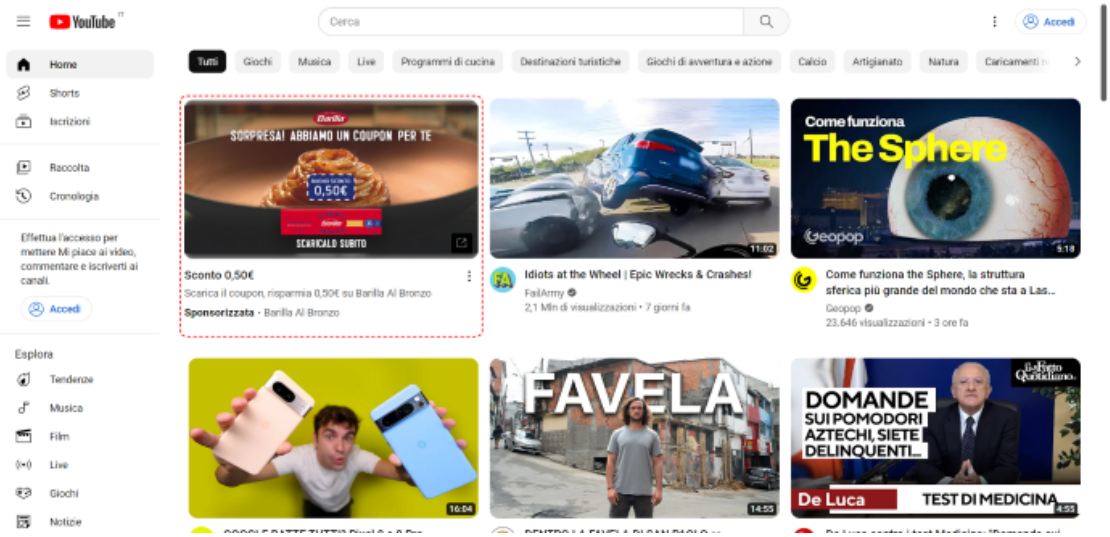

Figure 4.7: A red dashed border surrounding an ad in the homepage.

the available services for web, i.e., Firebase Realtime Database[7]. It is a database hosted in the cloud. Data is synchronized in real-time to every connected client and stored as JSON. One Realtime Database instance is shared by all users when a cross-platform apps using our JavaScript, Android, and Apple platforms SDKs

[7]https://firebase.google.com/docs/database?hl=en, last visited on Sep 30, 2023.

is created. This also ensures that all clients always have the most recent data available.

The first thing I want to mention is the user data that will be collected during the user study: time spent on YouTube, amount of scrolling, number of clicks, number of videos played, and number of interactions with redesigned elements, i.e. buttons to pause Infinite Scroll, Neverending Autoplay and Disguised Ads. Another important piece of information is the user token generated the first time a new client uses the extension through the JavaScript Crypto library. All of this data is stored in a JavaScript object known as "session". Each session, within the scope of this project, stores the aforementioned data in a time window that lasts from the moment a YouTube page is opened until the user navigates or switches to a non-YouTube page. These sessions are then stored in an array and periodically saved to Firebase. Afterward, the array is emptied.

After these premises, I would like to simply list and briefly describe the main functions of this part of the extension:

- `trackTimeSpent(userId)`: this function takes a user token as input and tracks the amount of time the user spends on YouTube. It does this by using the `chrome.windows` API to get the currently focused window and tab. If the active tab is a YouTube page, the function increments a counter that tracks the seconds spent on the platform. If the user leaves the YouTube tab or closes the Chrome window, the function stops the timer and saves the session data.

- `scrollInSession()`: tracks how many times a user scrolls on a page during a session by increasing the corresponding counter after having received a `scrollEvent` message.

- `clickInSession()`: the same as before, but it increases the current session's counter of clicks every time a `clickEvent` message is received.

- `videoPlayedInSession()`: tracks how many videos are played during a session by increasing the corresponding counter every time a `videoPlayedEvent` message is received.

- `scrollPauseInSession()`: each time the button to stop loading new contents is clicked in a session, a `scrollPauseEvent` message is received and the corresponding counter is increased.

- `autoplayPauseInSession()`: each time the button to make a pause at the end of a video is clicked in a session, an `autoplayPauseEvent` message is received and the corresponding counter is increased.

- `adsPauseInSession()`: each time the button to hide the ads in the homepage is clicked in a session, an `adsPauseEvent` message is received and the corresponding counter is increased.

- `scheduleUpload()`: given a user token, it schedules the upload of the client's session data to Realtime Database. This can be done by checking the sessions array every minute. If the sessions array is not empty, the function uploads the session data to the database and then clears the array. The function works by first getting the current date and then calculates the total amount of time spent, scrolls, and clicks for the user by iterating over the sessions array and summing the values of the corresponding properties for each session. Next, a reference to the user's data in the database is retrieved. If the user's data already exists, the function updates the properties with the new values. In case the client's data is nonexistent, a new entry for the user is created.

4.5 Other libraries

In this section, I will discuss external libraries employed in creating *TubeWizard*, i.e., jQuery[8] and Mutation Summary[9].

4.5.1 jQuery

jQuery is a JavaScript library created to make event handling, CSS animation, Ajax, and DOM tree navigation and manipulation easier. It is open-source software that is available for free under the MIT License. jQuery is utilized by 77% of the top 10 million websites as of August 2022 [85]. Some of the things that jQuery can do include:

- **Select and manipulate HTML elements**: finding and changing HTML elements on a page is simpler. For instance, you can edit an element's text, add or remove classes, or hide or show components quicker.

- **Handle events**: jQuery makes it simple to manage page events like clicks, hovers, and keypresses. When these events take place, actions can be triggered using this library.

- **Animate elements**: HTML elements on a page can easily be animated. For instance, you can resize, slide up or down, or fade in or out items.

[8]https://jquery.com/, last visited on Sep 22, 2023.

[9]https://github.com/rafaelw/mutation-summary, last visited on Sep 22, 2023.

- **Make Ajax calls**: Making Ajax requests to a server is simple with jQuery. You can change a page with Ajax calls without having to reload it.

JQuery is an extremely versatile library that may be used for a variety of tasks. It is a well-liked option for web developers because it is simple to learn and use and has a strong community that supports it.

For the reasons mentioned earlier, jQuery was used in certain parts of the code to retrieve and insert elements into the DOM, and to apply and remove styles rapidly, intuitively, and flexibly. This might not always have been easily achievable using standard DOM manipulation APIs. For example, it was heavily utilized in the script files for redesign and nudging.

4.5.2 Mutation Summary

The Mutation Summary JavaScript library is a lightweight library that makes it easy to observe and respond to changes to the DOM. It is built on top of the DOM Mutation Observer API, which is supported by all major browsers. Work with DOM mutations is made simple by a number of features offered by the Mutation Summary library, including:

- an easy-to-use API for handling mutation responses;
- the capacity to filter out and disregard mutations in which you have no interest;
- automatic debouncing of mutation notifications, to improve performance and avoid overloading the application;
- the capacity to group mutations in batches, which enhances performance and lowers the frequency of application updates.

A new instance of the `MutationSummary` class must be built in order to use the Mutation Summary library. The observer can then be connected to a particular DOM element or subtree using the `observe()` method. Once linked, the observer will begin keeping an eye out for DOM changes. The callback function specified in the `observe()` method will be called whenever a mutation takes place by the observer. A single object containing details about the modification will be passed as an input to the callback method. The kind of mutation, the target DOM element, and a list of all altered attributes are all included in this object. To respond to a mutation, it is possible to update the application using the data from the callback function, for instance by changing an element's wording, hiding or exposing an element, or disabling a button.

The following is an example of how to use the Mutation Summary library.

```
// Create a new MutationSummary instance
const mutationSummary = new MutationSummary();

// Observe the element with the id "my-element"
mutationSummary.observe(document.getElementById("my-element"), {
    // Callback function that will be called when the element changes
    callback: function (mutations) {
        // Update your application in response to the mutation
    }
});
```

Listing 4.1: Mutation Summary example.

To conclude, the Mutation Summary library is a powerful tool for working with DOM mutations. It is easy to use and provides a number of features that make it ideal for a wide variety of applications, for example updating a real-time chat feed in response to new messages or a table of data in response to changes to the underlying data, refreshing a navigation menu in response to changes to the user's permissions rather than implementing a live search feature that updates the results as the user types.

Due to the functionality it provides, the Mutation Summary library was used, for instance, to observe and track various changes in the grid containing the video cards on YouTube's homepage in the context of the Infinite Scroll redesign strategy. In that way, it was possible to hide and later correctly redisplay the videos.

Chapter 5

Evaluation of Implemented Artifacts

This chapter explains the goal, the methods, and the results of the user study that was conducted following the implementation of *TubeWizard*. Each participant in the experiment mentioned above had to install the extension on Google Chrome and use YouTube as usual, while background data on their usage was gathered.

5.1 Goal of the study

This final field experiment aims to provide a comprehensive assessment of the effectiveness of the developed extension. Unlike DSCTs, which have limitations as they focus on preventing user contact with a given website or app without addressing internal attention-capture strategies, *TubeWizard*'s primary objective is to empower users in their everyday use of social networks. By providing users with this knowledge, it encourages them to make more informed decisions about their online activities and take control of their digital well-being. Through its functionalities, i.e., redesigns and nudges, the extension aims to promote a healthier relationship with technology and incentivize users to strike a balance between their online and offline lives.

5.2 Methods

This section is dedicated to providing a comprehensive overview of the research design, data collection, and analysis procedures employed in this study. It outlines the framework and methodology used to investigate the research questions and objectives of this study.

5.2.1 Participants

The target population for the field study was primarily focused on individuals who own a computer, are familiar with its basic functions, and have a basic knowledge of the English language. So, a good profile of the people I was looking for should meet the following requirements:

- age: 18-29 years old;
- education: high school diploma or bachelor's/master's degree;
- gender: irrelevant;
- use computer for daily activities;
- watch videos on YouTube approximately daily.

A text message with the essential details required to participate in the study was sent to some WhatsApp groups belonging to my social circle in order to recruit participants. Specifically, the message included a high-level overview of the study's objectives, and explained the type of data the extension collects.

In total, 14 users were available to took part in the *TubeWizard*'s in-the-wild trial, so I created a dedicated WhatsApp group for this experiment, keeping them constantly informed and providing them with all the necessary support and materials, e.g., questionnaires, to complete the study effectively.

After having signed an informed consent form before participating in the study, users were asked to complete a pre-test questionnaire: a basic survey to gather demographic data like gender, age, profession, and educational background. The average age of the participants was 22.5 (SD = 1.34), with 7 males and females. Almost all participants were studying or working in various fields, ranging from engineering to medicine, from humanities to economics. Take a look at the column graphs in Figure 5.1 for further details. The majority of participants were students (11); there were two workers, and just one person who was both a student and a worker at the same time. Nine and five respondents, respectively, said that they had earned a high school diploma and a bachelor's degree. In Figure 5.2 you can observe details regarding the percentage distributions of these data.

Once participants had been screened, I gave them instructions on how to install the extension on their computers, i.e., a brief video tutorial demonstrating such a process on Google Chrome.

5.2.2 Structure of the study

The field experiment's protocol is summed up in Figure 5.3. Three separate, 4-days phases composed the test:

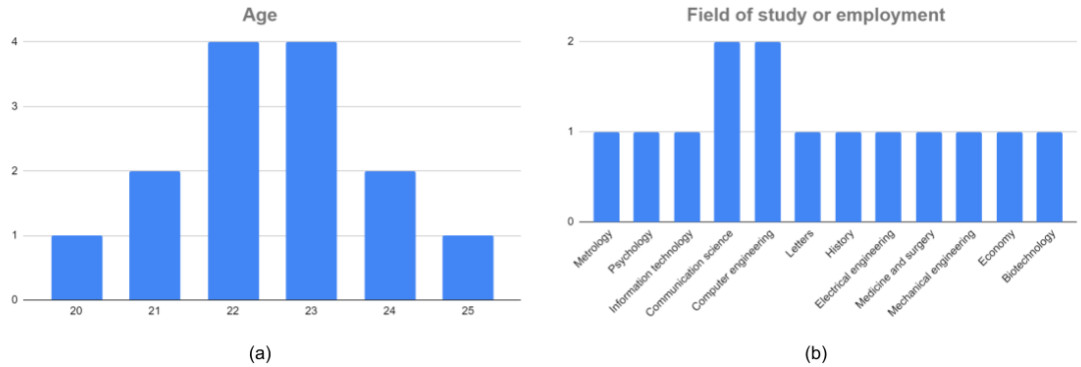

Figure 5.1: Age (a), and field of study or employment (b) of the study's participants.

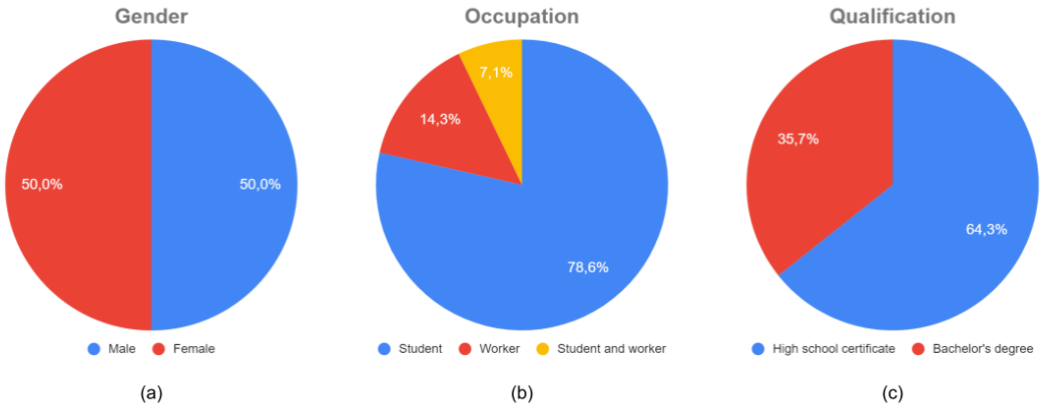

Figure 5.2: Gender (a), occupation (b), and qualification (c) of the study's participants.

- **Control**: 4 days in which *TubeWizard* operated in the background, gathering data on YouTube activity without putting any self-control measures into place;
- **Redesign**: 4 days in which *TubeWizard* provided additional features on YouTube in order to limit the effects of the chosen damaging patterns;
- **Nudging**: 4 days in which *TubeWizard* highlighted the selected damaging patterns on YouTube as part of the nudging strategy.

The first 4 days of the experiment were designated as the control phase, which was used as a reference to compare the effects of the two tactics that were put into practice on YouTube. In order to mitigate any biases across the tested techniques, participants were separated into two groups: the first group underwent the redesign

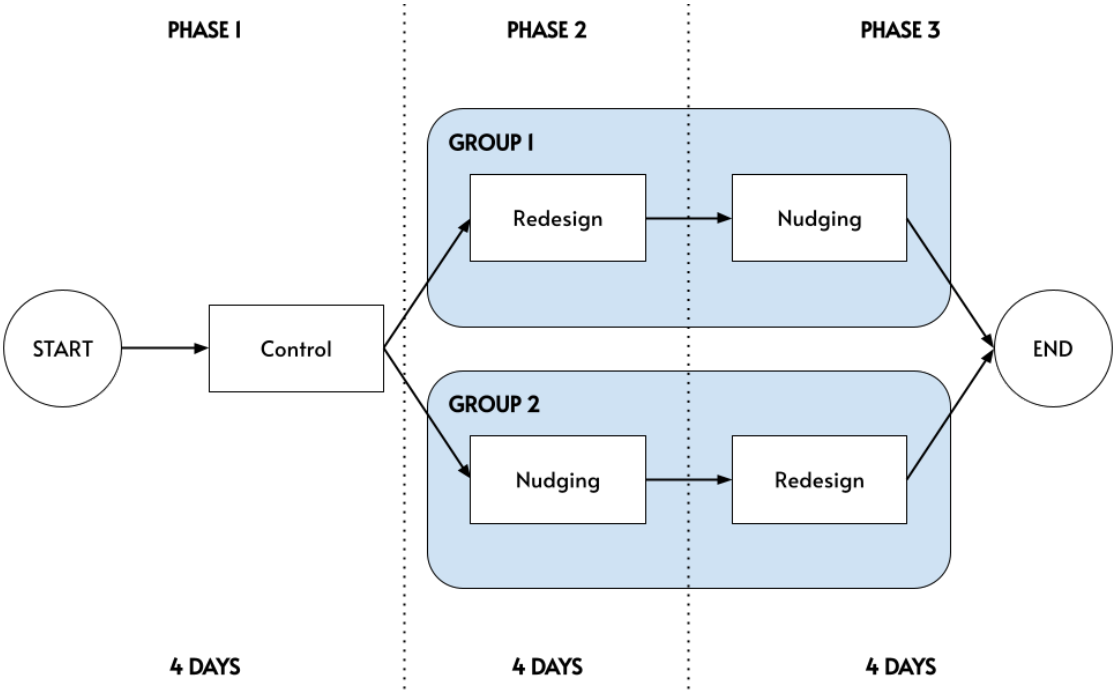

Figure 5.3: The process used in the *TubeWizard*'s field study.

approach first, followed by the nudging one, and the second group faced the nudging strategy first, then the redesign one. Such a procedure was automatically carried out by the extension.

5.2.3 Acquired metrics

I gathered various metrics over the course of the twelve days regarding the effects of nudges and redesigns that were put into place on YouTube. To be more precise, *TubeWizard* recorded every user session on the website, allowing me to compute statistics such as the mean daily time spent on the platform. I furthermore gathered the number of scrolls, clicks, videos played, and clicks on the redesigned buttons that users made on the interface. See the Firebase section in the previous chapter for deeper insights. These set of data were then utilized to determine whether the usage of a certain technique affected participants' interactions with YouTube in addition to how much time they spent using it.

Additionally, I invited participants to complete a post-test questionnaire at the conclusion of the field study. To learn more about users' preferences for the two suggested tactics, I included open-ended survey questions in the questionnaire, such as "Did the Chrome extension impact your perception of the time you spent on YouTube? If yes, please explain how.", "Did you feel more in control of your

YouTube usage with the Chrome extension? Why or why not?", and "Overall, which of the two strategies has aided your sense of agency the most?".

5.2.4 Pre-test hypotheses

I predefined a number of certain hypotheses to direct the inquiry into how redesign and nudging methods might affect user experience on YouTube, in accordance with best practices used in previous work [78, 83]. I was able to specify a study protocol ahead of time and avoid making assumptions after the data were known because to this process [86].

H1 - Time Spent. My initial set of theories focused on how much time people spent on YouTube. I predicted that the two self-control techniques that were put into practice would be able to shorten the average daily time spent in comparison to the control phase, with the nudging approach having a more noticeable impact due to its more graphical nature. In conclusion, I anticipated the following hypotheses:

- **H1a**: `timeSpent(control) > timeSpent(redesign)`;
- **H1b**: `timeSpent(control) > timeSpent(nudging)`;
- **H1c**: `timeSpent(redesign) > timeSpent(nudging)`.

H2 - Scrolls. My second set of assumptions focused on the number of scrolls on the YouTube website. In comparison to the control phase, I anticipated that the two self-management techniques that were put into practice may lower the average amount of scroll per minute. Once more, I reasoned that since there was the chance to stop loading new contents on the homepage, the effect could be more noticeable in the redesign strategy. At the end, I projected the following hypotheses:

- **H2a**: `scrolls(control) > scrolls(redesign)`;
- **H2b**: `scrolls(control) > scrolls(nudging)`;
- **H2c**: `scrolls(nudging) > scrolls(redesign)`.

H3 - Clicks. The number of clicks the YouTube was the subject of my third set of assumptions. As with the previous series of theories, I expected a decrease in the average number of scrolls per minute with respect to the control phase. I thought that the effect could be more pronounced in the nudging phase as there was no need to interact with buttons like in the redesign one. Finally, I put out the following hypotheses:

- **H3a**: `clicks(control) > clicks(redesign)`;
- **H3b**: `clicks(control) > clicks(nudging)`;
- **H3c**: `clicks(redesign) > clicks(nudging)`.

H4 - Videos Played. My final set of assumptions concerned the number of videos played. I anticipated that both of the self-monitoring techniques would be able to reduce the average daily number of videos played compared to the control phase, with the make a pause feature of the redesign strategy having a more pronounced effect. Lastly, I proposed the following hypotheses:

- **H4a**: `videosPlayed(control) > videosPlayed(redesign)`;
- **H4b**: `videosPlayed(control) > videosPlayed(nudging)`;
- **H4c**: `videosPlayed(nudging) > videosPlayed(redesign)`.

5.3 Results

With the use of the information gathered and the responses provided by the participants in the post-test questionnaire, I was able to use both objective and subjective metrics to triangulate the experiences of 14 research participants.

5.3.1 Quantitative results

Table 5.1 presents the daily average time spent, the number of scrolls and clicks per minute, and the number of videos played on YouTube. This data was gathered as part of the *TubeWizard* field study in the three research conditions — control, redesign, and nudging.

There was a statistical difference in the average amount spent on YouTube per day in both the nudging and redesign strategies. In particular, the *TubeWizard* extension resulted in a reduction in the amount of time users spent on YouTube: participants used the website with the redesign strategy for an average of 60.81 minutes per day (-13%) and with the nudging strategy for an average of 46.80 minutes (-33%) compared to the control phase (69.72 minutes). These decreases validated H1a, H1b, and H1c.

The redesign approach resulted in a considerable decrease in YouTube scrolls, verifying H2a: 16.89 scrolls per minute (-68% over the control phase). H2b and H2c were confirmed by a more modest loss in the average number of scrolls during the nudging phase: 40.17 scrolls per minute (-23%).

Both the nudging and the redesign strategies reduced the number of clicks in comparison to the control phase: the nudging method reduced clicks per minute

	Time spent [min]	Scrolls per minute [#]	Clicks per minute [#]	Videos played [#]
Control	69.72 (SD = 53.20)	52.30 (SD = 128.22)	2.42 (SD = 5.86)	14.55 (SD = 22.61)
Redesign	60.81 (SD = 55.99)	16.89 (SD = 16.10)	0.89 (SD = 0.83)	6.08 (SD = 4.89)
Nudging	46.80 (SD = 45.47)	40.17 (SD = 70.14)	0.81 (SD = 0.82)	7.62 (SD = 9.44)

Table 5.1: A summary of the *TubeWizard* field study's findings.

by 67%, while the redesign strategy decreased clicks per minute by -63%. These findings demonstrated H3a, H3b, and H3c.

The nudging and redesign strategies both had a demonstrable influence on the average number of videos participants watched on YouTube each day. Specifically, the *TubeWizard* extension resulted in a significant decrease in the number of videos played by users: compared to the control phase (14.55 videos played on average), participants played 6.08 videos per day on average (-58%) while using the redesign strategy, while they played 7.62 videos on average (-48%) with the nudging strategy. These decreases verified H4a, H4b, and H4c.

A daily summary of the results of the *TubeWizard* field study is highlighted in Figure 5.4.

Lastly, even if limited, but still sufficient to produce their effects, there have been some interactions with the redesign phase newly introduced elements, for each of which I reported the average: 1.01 (SD = 1.03) clicks on the button to stop Infinite Scroll, 1.64 (SD = 1.49) clicks on the button to pause Neverending Autoplay, and 0.94 (SD = 0.99) clicks on the button to hide Disguised Ads.

5.3.2 Qualitative results

Participants in the post-test questionnaire said that *TubeWizard* enhanced their YouTube experience by helping them use it more thoughtfully.

Overall, participants reported that the extension affected their content consumption habits, e.g., the type of videos watched, the duration of sessions, etc., and helped them become more conscious of how they used the platform, encouraging them to minimize distractions. Only for a few of them, the extension did not impact their perception of the time they spent on YouTube, nor did it make them feel more in control of their YouTube usage. This is because they claimed to use YouTube very selectively, as they only "*follow specific channels*" (participant 11), or because they use it as "*background noise for other activities, such as studying*" (participants 6 and 13).

In general, the strategy that has aided participants' sense of agency the most turned out to be the nudging one, with the visual effects assisting participants in realizing that they are "*unconsciously wasting time looking for and watching new videos*" (participants 2 and 7). Nevertheless, the redesign strategy has also been

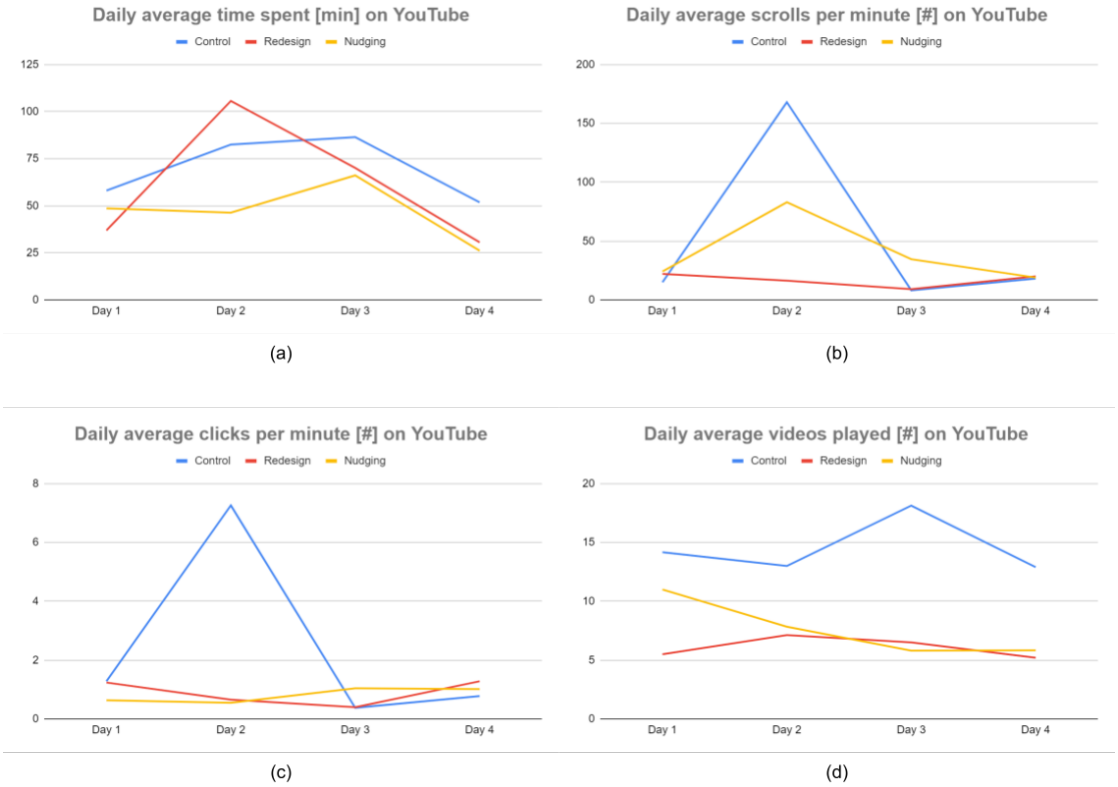

Figure 5.4: Daily average time spent (a), scrolls per minute (b), clicks per minute (c), and videos played (d) on YouTube in the control, redesign, and nudging phases.

appreciated, allowing "*control over certain aspects that were previously accepted passively*" (participant 9).

Moreover, almost all participants would had considered continuing to use *TubeWizard* beyond the test period as it "*provides a useful service without excessively impacting the original interface*" (participant 2). As a result, the attendees were more likely to recommend the extension to others.

5.4 Discussion

This research opened the way for the adoption of different tactics aimed at helping people self-regulate how they use digital devices, with an emphasis on ACDPs present in YouTube. In this section, we first go over the study on two critical gaps in the field of digital wellbeing research: creating innovative adaptive self-control solutions and raising awareness rather than restricting use. Next, we address the shortcomings of the research and point out potential avenues for future development.

5.4.1 Creating innovative adaptive self-control solutions

Although both tactics were successful in changing usage behaviors, the study's participants favored the nudging strategy. By increasing the visibility of ACDPs, this strategy may aid users in comprehending the alluring qualities of websites like YouTube that promote obsessive behavior. Because it is less invasive and doesn't offer new features, it also encourages meaningful and purposeful usage sessions.

Nevertheless, quantitative testing of the redesigned artifacts shows that this kind of approach is clearly promising. Thus, the results and debates in a recent work by Monge Roffarello and De Russis [83] about the necessity for adaptable and adaptive self-control systems are also reflected in this work.

Depending on their present intention or attitude, users of adaptable self-control solutions can actively activate a method, like adding a nudge or changing to a different design. Although an adaptable interface for YouTube's mobile app was investigated by Lukoff et al. [78], it is unclear how useful this interface would be for various tactics, devices, and platforms.

The next big thing in user experience may be adaptive self-control solutions, which let users automatically choose a course of action that seems promising for them in a particular situation. Models of customized prediction may be used in this. It is possible to predict when a user is locked in a passive usage session or is pursuing a specific, intentional objective by examining usage data, as demonstrated by HCI researchers [87]. Higher control mechanisms for specific intentions and lower control mechanisms for non-specific purposes — such as requiring a search-only interface for instrumental use [8] — should ideally be provided via user interfaces.

5.4.2 Raising awareness rather than restricting use

Although they frequently concentrate on lowering users' time spent on digital devices [8, 78, 79], Digital Self-Control Tools (DSCTs [16]) are a well-liked method for encouraging digital self-control. Commercial DSCTs, like those found in iOS [84] and Android [30], let users create self-imposed timers to prevent using particular websites or apps. This strategy might, however, interfere with the functionality of the app, which may not be damaging to users' digital wellbeing [78]. Furthermore, it doesn't deal with the interface's internal ACDPs or other core problems [8]. Therefore, in order to promote users' digital self-control, an improved strategy is required.

The study's findings are important because they push digital wellbeing researchers to think beyond typical DSCTs and screen time measurements [88, 89] by emphasizing "*quality of time, not just quantity*" [78] in the ongoing discussion on digital wellbeing. In fact, the redesign and nudging techniques of the *TubeWizard* Chrome extension encouraged more mindful YouTube usage, lowering distractions and raising awareness among users.

These results are comparable to those of other studies, such as the one created by Monge Roffarello and De Russis [83], who created the browser extension called *inControl*, which allows users to cultivate digital self-control on Facebook and YouTube. As long as the user kept scrolling, the extension gradually darkened the background using a nudging technique. Additionally, the extension used a redesign method, suppressing recommendations for guilty pleasures and suggesting simple interfaces to encourage purposeful use. On the one hand, participants were able to decrease their time spent on Facebook and YouTube and their scrolling habits thanks to both tactics. On the other hand, even though participants spent less time overall on Facebook than they did during the control phase, the redesign strategy caused participants to click on the social media platform more frequently and spend a little more time on YouTube. All things considered, this implies that in addition to promoting self-control, a simple interface encouraged users to engage with Facebook and YouTube more deliberately.

5.4.3 Limitations and future work

There could be restrictions with this work. Only twelve days were spent with the relatively small group of young adults that participated in *TubeWizard*'s in-the-wild trial. The above choices, apart from the duration, match those of the majority of prior studies concerning digital self-control tools: previous research [79], for instance, has discovered that the usual length of DSCT investigations is 21 days, and that the majority of participants are youthful college students. I do, however, agree with the recommendations made by earlier work [79, 83], which recognize the necessity of examining the generalizability of our results and suggested self-control techniques in more extensive and prolonged investigations involving a diverse population.

In addition, using a within-subject method, all intervention strategies and a control period were experienced by each participant in the experiment. It's possible that the findings were only suggestive, and additional between-subject studies, i.e., different people test each condition so that each person is only exposed to a single strategy, involving control groups would be required to support or contradict them.

At last, to better understand their effects and user preferences, future studies could conduct an empirical comparison between the suggested techniques and conventional DSCTs.

Chapter 6

Conclusions

This research aimed to go beyond the limitations of conventional digital self-control tools (DCSTs) that are primarily based on screen time restrictions. It focused on addressing the underlying causes of technology overuse, specifically the attention-capturing techniques employed by current digital platforms. Instead of simply blocking user interactions, the goal was to enhance user awareness and encourage more purposeful and meaningful use.

To achieve this objective, the study introduced *TubeWizard*, a Chrome extension designed to target the YouTube website. Two distinct strategies for digital self-control were employed:

- **redesign**: the mitigation strategy focused on reducing the impact of the addictive features of the platform, such as Infinite Scroll, Neverending Autoplay, and Disguised Ads. It aimed to create a more balanced and controlled user experience.
- **nudging**: this approach aimed to gently guide users towards more intentional and mindful use of YouTube. It sought to counteract the aforementioned attention-capture patterns.

The research conducted a field study involving 14 participants to evaluate the effectiveness of *TubeWizard*. The results of this study provided evidence that both the nudging and mitigation strategies had the potential to influence users' behaviors on YouTube positively. They encouraged more intentional and active use of the platform. This suggested the feasibility of transitioning from traditional DCSTs to alternative strategies that could better support long-term digital well-being.

In essence, the study offered promising insights into how we can address technology overuse issues by not only restricting screen time but also by addressing the fundamental mechanisms that make digital services addictive. It emphasized the importance of fostering user awareness and promoting healthier digital interactions.

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