Starving the Newsfeed for Social Media Detox: Effects of Strict and Self-regulated Facebook Newsfeed Diets

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ABSTRACT

Doomsurfing, doomscrolling or zombie scrolling. These new additions to the tech vocabulary have become part of our everyday routine, scrolling endlessly through social media feeds. Furthermore, some users report a sense of compulsion, a decrease in mental wellbeing and an increased sense of distraction. A common complaint among users harks back to the Facebook newsfeed. In a field experiment with real Facebook users (n = 138), we investigate the difference between a strict newsfeed diet (where the newsfeed is automatically reduced to a minimum) and self-regulated newsfeed diet (where the newsfeed is reduced, but users can then manage its content). Our results indicate that both of these newsfeed diets are effective at reducing the time spent on Facebook's platform (−64% for the strict diet, −39% for the self-regulated diet). Our findings also suggest that these design interventions come with positive and negative user experiences such as increased self-awareness and fear of missing out (FOMO).

KEYWORDS

Dark patterns, Digital Detox, Infinite newsfeed, Doomscrolling, Unfollow mechanisms, Social media, Digital Nudging, Multi-device, Digital Wellbeing, Facebook

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1 INTRODUCTION

In some countries, the self-reported averages of social media use are 3–4 hours a day [27]. In 2019, average users reportedly checked their phones every 10 minutes, with 18–24-year-olds twice as often.[1]

The large-scale societal consequences of increased social media consumption range from more positive to negative use-cases such as habits [7, 67] to more disrupting mental health problems [46, 81] and degraded social interaction [48]. At the heart of this issue lies compulsive social media use which is a "*repetitive, ritualistic behavior involving an individual's inability to control, reduce, or stop the use of mobile [social media]*" [80].

Each user is potentially vulnerable to harmful use-cases through various reinforcement cycles when using social media platforms [43, 80]. During such reinforcement cycles, interactive technologies serve as a form of stimulus, compulsive usage becomes a response and the reinforcement cycle continues. Social media platforms are designed to maximize connections and time spent online leading to hyper-connectivity by employing user interface designs, sometimes referred to as dark patterns [11, 26, 60], i.e., designs that utilize knowledge of human psychology to trick individuals into an act that is not in their best interest [59, 60].

HCI researchers have previously pointed to Facebook's *infinite newsfeed* as a dark pattern [60]. The infinite newsfeed taps into three main characteristics of dark pattern as defined by Roffarello et al. [60]: (1) the design undermines individuals' autonomy and distracts them from their goal [60], (2) individuals experience that time has passed and they have no control over it [60] and (3) in retrospect, the design makes a person regret the time spent on the service [59]. In addition, infinite newsfeed negatively influences individuals' digital wellbeing [79]. As such, the newsfeed is likely to be among the factors that eventually lead people to use Facebook compulsively. In this paper we aim to better understand how newsfeed is related to time spent on Facebook and how a digital newsfeed diet, i.e., an intervention that reduces one's newsfeed, could be designed to reduce Facebook usage and potentially improve digital wellbeing. This leads to our overarching research question.

RQ: How does newsfeed restriction affect Facebook usage?

[1] Asurion-sponsored survey by Solidea Solutions in August 2019: shorturl.at/uIZ15

This overarching question leads to three sub-questions. First, how do different types of newsfeed restriction (abstinence vs moderation) affect time spent on Facebook? Second, how does newsfeed restriction affect user experience? Third, how does newsfeed restriction affect time spent according to users' compulsion to use Facebook? In this paper, we attempt to answer these questions by taking a design science research methodology (DSRM) approach [30, 34, 35, 37, 38]. In DSRM, the artifacts that impact people and organizations are created and evaluated in order to solve identified research problems [68] in six steps. This article is structured following these steps. The introduction covered the first step, namely the definition of the problem. The second step, i.e., defining the objective of the problem, is covered in Section 2, which lays out our hypotheses. The third and fourth steps, i.e., design of the solution and demonstration, are covered in Section 3. The fifth step, i.e., the evaluation of the solution, is split between Section 4, which presents the evaluation setup, Section 5, which tests the hypotheses, and Section 6, which provides qualitative insights into the user experience through a thematic analysis. Finally, the sixth step, i.e., communication of the findings, is covered in the discussion in Section 7 and the conclusion in Section 8.

2 RELATED WORK & RESEARCH OBJECTIVES

Here, we describe relevant prior work, which led to the six specific research hypotheses that we tackle in this paper. In particular, we review work that relates social media use to compulsive use, before we give an overview of attempts to redesign the newsfeed to address this issue and how this could relate back to compulsive use and user experience.

2.1 Social media & compulsive use

There has been a lively debate among scholars about where chronic social media usage ends and usage more akin to "*addiction*" begins [47, 78, 80]. However, there seems to be substantial agreement among HCI researchers that social media platforms are designed in a way that facilitates compulsive use [6, 51, 52, 70, 78].

Typically, compulsive social media use is defined as the "*inability to self-regulate the use of the social media platform*" [42], that is, the user cannot control how frequently they use the platform or how long they spend on it. Compulsive social media use is an important societal concern because users facing it might have psycho-social and professional consequences [31, 80]. We previously mentioned that other researchers have theorized that compulsive social media usage happens through a series of reinforcement cycles, with interactive technologies serving as a form of stimulus, and compulsive usage becomes a response and the reinforcement cycle continues. We posit that the newsfeed on Facebook is one such interactive technology. While several previous studies have confirmed a strong correlation between a variety of compulsive use measures and self-rated time on social media [24] – we want to validate this assumption by examining the relationship between compulsive use measures and actual time spent (by real users) on a well-established social media platform: Facebook. Previous scholars have also argued for the importance of validating the association between compulsive use and actual user behavior on social media platforms [10, 80]. Therefore, we hypothesize the following:

H1: Compulsive use is positively correlated with time spent on Facebook.

2.2 Redesigning the newsfeed

An important design feature for prolonging usage time on social media platforms comes through the newsfeed [62]. While the feature itself is the principal entry-point for a Facebook user, a recent survey suggested that it was also one of the features that tends to be associated with regret for the user [59]. Several previous studies have suggested the removal or reconfiguration of the Facebook newsfeed as a potential context for design researchers to tackle. Suggestions in the HCI literature range from complete removal [20], contextual removal that is dependent on the given user's goals [55], to adding various filtering options [51, 55, 70]. For example, both scholars and sampled users have made suggestions around configuring the newsfeed to only show content from close personal friends [51, 70]. In another study, Lyngs et al. conducted a user experiment where different Chrome extensions were used to compare a control group to goal reminders and a completely hidden/blocked newsfeed [55]. Here, a majority of sampled users suggested that they wanted more granular control over the Facebook newsfeed. In short, this newsfeed blocking intervention was effective when it came to decreasing users' visit length on Facebook's site but also led to fear of missing out (FOMO). Another study concerned the design and evaluation of a Chrome extension that allowed to hide some parts of the Facebook user interface or remove colors to make it less appealing [70]. When considering how users spend their time and attention across apps, previous researchers have characterized design interventions along a spectrum ranging from internal to external [51]. External mechanisms entail monitoring problematic apps from the outside, and informing or notifying the user, e.g., setting a maximum duration on an app, or viewing the time spent on an app. Other external examples include the use of the phone's vibration to signal to the user that they have spent enough time on Facebook [66], framing the feedback negatively or positively [41], locking users out of apps [52] and locking users out of the device [77]. Internal design mechanisms would entail redesigning certain features of a problematic app directly inside the app, e.g., removing the newsfeed. Such internal mechanisms might remove more problematic aspects from a given app, while still retaining its most important benefits [51]. HCI researchers have highlighted that Google Play, Chrome Web and Apple App stores have created a vast marketplace for tools that help users in their online struggles for self-control (see [53, 54] for reviews of such tools).

In this research context we aim to change an internal design mechanism, more precisely the dark pattern such as infinite newsfeed that leads to mindless scrolling [60, 65]. We argue that by designing an artifact that restricts the newsfeed, that is, that reduces the content of the newsfeed from friends, pages and groups, users would be less exposed to variable rewards [1, 70] thereby breaking the inexhaustible reinforcement cycles of anticipation, uncertainty and feedback. We provide two versions of the newsfeed restriction artifact: (1) a *strict newsfeed diet* that reduces the newsfeed to the minimum and (2) *a self-regulated newsfeed diet* that reduces the newsfeed to a minimum, but lets users fill it with

updates from people, pages and groups that the users opt-in to follow (as opposed to the system's default setting to follow all connections). In both cases, we hypothesize that the restriction will reduce time spent on Facebook:

H2a: A strict newsfeed diet will decrease time spent on Facebook.

H2b: A self-regulated newsfeed diet will decrease time spent on Facebook.

2.3 Newsfeed diets & compulsive use

Previous research investigating various digital self-control artifacts hinted that such tools seemed especially useful for users who experienced the most intense struggles for self-control or labeled themselves as addicted [53]. This finding from sampling public user reviews can be contrasted with previous research on habits. Here, literature points to the general difficulty of changing strong (vs weak) habits [84]. That is, stated intentions are at odds with actual behavior in the presence of strong habits, and this is especially salient when the environment is stable, because the cues triggering the habitual response typically come from the environment [19]. In the case of newsfeed restriction diets, the environment stays stable; only the content of the newsfeed changes. Therefore, we expect more compulsive users to trigger their habitual response (i.e., spend time on Facebook) whatever the content and the restrictions applied to their newsfeed. This should be less the case for less-compulsive users, whose time on Facebook should be more affected by newsfeed restrictions. This is reflected in other, digital behavioral interventions, such as digital nudges, which tend to be less effective when habits are established [16].

H3: The newsfeed diets will affect less- (vs more-) compulsive users' time spent on platform to a greater (vs lesser) extent.

2.4 Newsfeed diets & user experience

Finally, we believe that a potential consequence of imposing a *strict* newsfeed diet, where users have no say in how the newsfeed is restricted, may adversely impact the user experience. While this intervention is not expected to affect usability components such as ease of use, users might potentially feel FOMO [13, 55], or difficulty to connect with friends and family. One way to address potential issues related to FOMO or connecting with important people in one's life is to take a self-regulation approach to the newsfeed instead of a strict restriction. A recent study that focused on increasing users' sense of agency on Twitter with internal vs external design mechanisms found that only internal mechanisms significantly increased users' sense of agency [86]. Findings from the same study suggest that usability issues were most frequently mentioned when users feel as if they are not in control [86]. The self-regulated newsfeed diet lets users define which connections to follow. In doing so, it gives users a sense of control, which is important to user satisfaction [21, 51, 86]. Moreover, HCI has long emphasized the importance of a sense of control over how users experience the interaction with technology [50]. The users want to feel that they are in charge and that the system responds to them [50]. This leads us to the following hypotheses:

H4a: A strict newsfeed diet (vs no diet) will negatively impact user experience.

H4b: A self-regulated (vs strict) newsfeed diet will positively impact user experience.

3 DESIGN & DEMONSTRATION

The problem statement pointed out that social media users tend to mindlessly spend too much time on social media because of the infinite newsfeed feature. The solution's main objective is to address this issue by reducing the newsfeed.

3.1 Newsfeed mechanics & design

Social media platforms use different techniques to populate the user's newsfeed. Even though the exact algorithms are not open to the public, they follow certain principles. At the center of such algorithms is the notion of following some content emanating from friends, pages or groups. When a user follows a certain contact – the user's newsfeed will contain updates from that contact. It should be noted that different social media platforms have different ways to call similar types of relations. Generally, social media platforms offer at least two types of relations: a relation that allows users to establish a contact with someone (called '*friends*' in Facebook, '*contacts*' in LinkedIn, or '*followers*' in Instagram) and a second one that allows to see or not see someone's update in one's newsfeed (called '*follow*' or '*unfollow*' in Facebook and LinkedIn and '*unhide*' or '*hide*' in Instagram). By default, these platforms generally establish the second relationship, i.e., showing people's updates in one's newsfeed, when the first relationship is established. In this paper, we use the term *contact* for the first relationship and we use the terms *follow and unfollow* for the second relationship. As such, the newsfeed is a rough function of the number of contacts that a user follows. In addition to updates from followers, a Facebook user's newsfeed is also populated with different sponsored posts, as most mainstream social media platforms are monetized through advertising.[2] In the context of Facebook, sponsored posts are personalized for users, based on different information such as stated preferences, demographics, location or previous online activity [57].

In some solutions, a browser extension can directly hide parts of the user interface (UI) such as the newsfeed [55, 70]. They can do this by simply modifying the HTML/CSS code on the client side. However, this type of solution has a limitation that makes it unsuitable for this study: The limitation is the fact that modifications are restricted to browser-based solutions and not applicable to native mobile apps, which is how many social media platforms are also used today. With the number of devices that allow access to social media content, data from a single device alone may not suffice to capture people's digital behavior [61]. One way to offer a cross-device solution is to provide a truly internal intervention that will, by definition, spread to all devices. One such approach to limit the newsfeed is simply unfollowing certain contacts. To unfollow means to stop seeing these contacts' posts in one's newsfeed. Unfollowing a contact does not remove you from each other's contacts list and it still allows you to go see your contacts' updates on their profiles. If a user unfollows every single contact, their newsfeed will be mostly empty, except for potential sponsored content.

To unfollow everything, users can navigate to a specific contact, but in some platforms it can be hard to find this unfollow option.

[2] In 2021, Meta generated more than 99% of their total revenues (USD 115.655 billion) from advertising [58]

To unfollow a contact, a Facebook user must currently navigate to the contact's profile, hover over "*Following*" (on a friend's profile) or click the "*Following*" button (on a page or in a group) near their cover photo and then select the "*Unfollow*" option [22]. This action then has to be repeated for each contact. Whereas the action of following a contact is the default state of affairs when a user adds a new contact, the unfollow procedure seems to suffer from lack of discoverability, which could be considered an example of another dark pattern [29]. With users following an average of over 300 friends, pages and groups on Facebook, repeating this manual procedure can also quickly become tedious [75].

3.2 Designing an automated unfollow solution

Automating the unfollowing process for large numbers of contacts could ease the process and could also address the cross-device issue. To enable this process to happen in a user-friendly manner, we designed a Chrome web browser extension that allows the user to unfollow all friends, pages and groups that they follow on one particular mainstream social media platform, namely Facebook. This extension was able to be downloaded and installed directly from the Chrome Web Store. From a user's perspective, the experience occurs as follows: once installed, the extension automatically unfollows a user's friends, pages and groups from Facebook, when the user opens Facebook via the Chrome browser, without any user interaction needed. Technically, the extension accesses the list of friends, pages and groups of a user through an authentication token. It then iterates through the list and performs POST requests for each friend, page and group to unfollow them. It should be noted that the process is not immediate, taking about 5–15 minutes to unfollow 300 friends, pages and groups (longer for users with many more friends, pages and groups).

By default, users are in what we are calling the '*self-regulated*' condition. That is, the extension unfollows all of the user's friends, pages and groups, and then the user can refollow anyone they please. For the purpose of the field experiment, we modified the extension in two ways: First, we added an extra prompt after the extension was installed and before it started unfollowing friends, pages and groups, in order to separate regular users and study participants, see Figure 1. The existing extension prompted regular users to directly go to Facebook after the installation, whereas study participants were instructed via an extra pop-up window to click a link so that they could enter a randomly assigned unique ID that they were given via a Qualtrics survey; this enabled their online behavior to be linked to their survey responses. Second, we modified the extension to assign study participants to three conditions based on their unique ID: 1) The default self-regulated diet, 2) A control condition in which the extension did not trigger any unfollow process, 3) A strict diet. To put users on the strict diet, we programmed the extension in such a way that it would unfollow all friends, pages and groups. If a new friend, page or group was added, or if an old friend, page or group was refollowed, the extension automatically unfollowed them. Finally, in order to allow users who use the extension to get their newsfeed back to normal, we designed a function to refollow everyone. Similarly to the unfollow process, this function iterates through all of the user's friends, pages and groups and refollows them one by one.

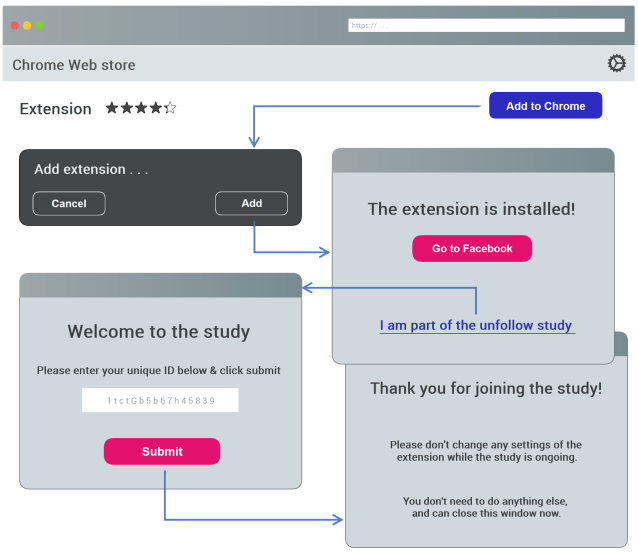

Figure 1: Mockup showing the installation of the extension: After adding the extension to the browser, three pop-up windows appeared where users (regardless of which condition they belonged to) had to click a link, input a unique code, and then close the final window

In addition to the core functionalities of the solution, we also designed infrastructure to measure the time spent on the Facebook platform for the purpose of the study on the site itself as well as on the iOS app. To measure time spent on the site (we focused on the Chrome web browser), we designed the web extension so that it would send time spent for each session to an analytics server. The extension typically performs a check every second to see if the browser's active tab is on the social media platform. If the extension detects a visit, a timestamp is created with an initial duration of 0 seconds. Then for every subsequent second on the site, the duration is incremented and sent to the analytics server.

To measure the time spent on the app (we focused on iOS devices), we implemented an automation process on the Apple shortcut app similarly to the methodology used by Purohit et al., [1, 71]. In a nutshell, the Apple Shortcut app allows the design of an automation that is triggered when a particular third-party app on the phone is opened or closed. The automation then wrote timestamps, every time the Facebook iOS app was opened and closed, in a CSV file that was stored locally on each user's phone. At the end of the study we simply asked users to submit this CSV file to inspect the time they spent on the app without the need to build a client server infrastructure for the mobile data.

4 EVALUATION

To evaluate the intervention and test the research hypotheses stated above, we conducted a three-week controlled field experiment with Facebook users randomly assigned to one of three independent conditions: the control condition (no diet), the strict newsfeed diet condition and the self-regulated newsfeed diet condition. The study was cleared with the university's ethics board beforehand. All data

was collected during June 2021. Participants were recruited through Prolific and were provided instructions for the study with Qualtrics surveys. Participation through the whole study was rewarded with USD 25.

4.1 Measures

In addition to demographic control variables, such as age and gender, the main variables that we measured were related to compulsive use, time spent on site/app and user experience. There are several existing scales for capturing problematic or compulsive use on the Internet [14, 15, 39, 56]. Also, Wang et al [80] built on such constructs to focus on mobile social networking services. We reused their scale and adapted it for one specific social media platform, namely Facebook. Every item for compulsive use was measured on a seven-point Likert-scale. To measure time spent on site/app, we added the daily time spent on the Facebook platform via the mobile device to the daily time spent on the Facebook platform via the browser to compute a single measure for each user, the average daily time spent on the Facebook platform for a given time period. To measure user experience, we used the system usability scale (SUS) [5] as well as an open question to let users report feedback in their own words about their user experience. Specifically we asked users to provide optional feedback on the best thing about the extension, the worst thing about the extension together with their overall impression.

4.2 Evaluation setup

The evaluation is divided in four main phases: (1) screening survey, (2) main survey, (3) the field experiment and (4) the exit survey.

First, participants filled out a short screening survey to confirm that they were interested in and eligible for the study. Owing to technical design choices, only Facebook users who accessed the platform with the Google Chrome browser and the iOS app were eligible. At that stage, it was already made explicit that their continued participation in the study could entail unfollowing all of their contacts on the platform.

Second, after this screening, a main survey was conducted. Users were asked to share demographic information, and fill out usability and compulsive use scales. Then they were asked to download, install, and configure the Google Chrome extension and Apple's Shortcuts app. As a verification procedure, each user received a random six-digit code to establish a link between the survey data and the behavioral data from the browser and the mobile app. During this installation, users were randomly assigned to one of the experimental groups using Qualtrics.

Third, the field experiment was performed. As mentioned previously, the field experiment had three randomized groups: no newsfeed diet (control), the strict newsfeed diet condition, and the self-regulated newsfeed diet condition. The field experiment was divided up as a seven-day baseline period, followed by a 14-day treatment period. During the baseline period, the extension remained idle for all three groups. The idea was to measure baseline daily average time on Facebook's site/app for each user. At the beginning of the treatment period, the different conditions were activated. For users in the control group, the extension was not activated and these users were told that they could continue to follow all their contacts. For users in the strict newsfeed diet condition, the strict version of extension was automatically turned on and it was communicated to this group of users that they would not be able to follow their contacts during the following 14 days. Similarly, for users in the self-regulated newsfeed diet condition, the extension was automatically turned on, but in this case in its self-regulation version which allowed users to refollow any contact they wanted. Users were again told explicitly about what was going to happen, i.e., that all their contacts would be unfollowed, but that they were able to refollow them during the succeeding 14 days if they wished to do so. As the Chrome extension's unfollowing procedure took around one hour for a thousand contacts, it could potentially take a long time for users with many contacts. We considered that the process of unfollowing contacts might take several days if users did not spend enough time on Facebook to unfollow all contacts on the day they installed the extension. To minimize interference of this process with their regular usage, we only use the behavioral data of the latter seven days of the 14-day intervention as treatment period data.

Fourth, at the end of the third week, participants completed an exit survey that contained the open user experience questions and they were shown how to upload their mobile usage data (the CSV file described above) and finally they were shown how to delete the Shortcuts automation and refollow their contacts if they wished to do so.

5 RESULTS

5.1 Study design and data overview

The Sankey diagram in Figure 2 summarizes the overall design of the study and the most important sources of data. The size of each pipe and node is proportional to the number valid responses, i.e., the size of the sample. The Sankey diagram is ordered from left to right in terms of sample attrition rate. That is, the pool of valid cases decreases from left to right in Figure 2. The data sources in Figure 2 are not necessarily in chronological order. In terms of chronology, the behavioral data collection (both mobile and browser) started right after the main survey and up until the exit survey. During the exit survey, the remaining users were asked to upload their CSV files from their mobiles, which is why the sample attrition rate increases after the exit survey.

The initial sample size for the screening survey was n = 1349 US Facebook users. In total, 327 users enrolled on the study by completing the main survey. Out of those, 296 users successfully downloaded/installed the Chrome browser extension. Just 256 users finished the exit survey and thereby provided valid answers to the attitudinal before/after variables. From these, we received valid mobile data from 138 users in total. The last number constitutes the final number of users for the study and, as the next section will show, this number slightly fluctuates, depending on the variable of interest. Despite the attrition rate in the study, the three randomized groups remained fairly balanced throughout the field experiment. Table 1 presents the descriptive statistics of variables of interest collected at the *baseline period* of the field experiment. This is mainly to ensure that the randomization procedure worked during the field experiment so that the intervention groups are comparable.

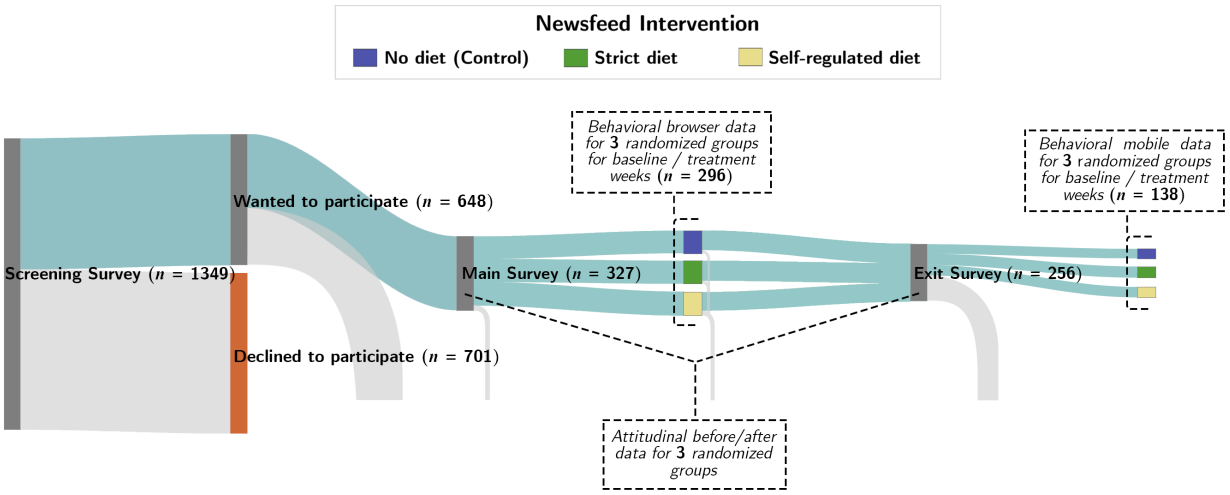

Figure 2: Sankey diagram [36] illustrating relevant data sources for the study, together with the sample attrition rate

Table 1 shows the sample medians ($\hat{m}$), averages ($\hat{\mu}$), standard deviations ($\hat{\sigma}$) and the number of valid cases (n) for each variable across the intervention groups. The high standard deviation for time on site/app shown in Table 1 reveal a very high variation of Facebook usage between users. Indeed, the measure ranges from roughly seven seconds to almost four and a half hours per day. Nevertheless, the average of 35.7 minutes per day that we observe is in line with figures of the Global Web Index report 2021, which shows that the average monthly time spent on Facebook is 19.5 hours, i.e., 39 minutes per day [28].

Table 1 also highlights that there seems to be a higher sample attrition rate in the control group compared to the treatment groups. While the control group is smaller, a χ^2goodness-of-fit test indicated that there were no significant differences in the proportion of valid cases in the three randomized intervention groups (42, 49, 47) when compared to the expected proportions of (46, 46, 46), $\chi^2(df = 2, n = 138) = 0.565$, p = 0.754.

In fact, Kruskal–Wallis tests and another χ^2-test detected no significant differences between the intervention groups on any of the listed variables in Table 1. We therefore conclude that the medians and proportions of these variables are reasonably balanced across the intervention groups at the baseline period of the field experiment.

5.2 Time on platform, compulsive use & newsfeed diets (H1–H3)

When performing tests for statistical significance, we followed the guidelines outlined by Benjamin et al. [9]. The relationship between time on site/app during the baseline period and compulsive use showed a significant correlation: $\rho = 0.390$, [95% CI: 0.233, 0.526], $n = 138$, $p < 0.001$. That is, high levels of time on site are associated with higher degrees of compulsive use. H1 is supported.

To conform to the assumptions of parametric models and tests: a natural log transformation was applied to the daily time on site/app variable. The results before and after the log transformation are visualized in Figure 3. The raincloud plots in Figure 3 combine the distribution curves, boxplots for indicating where the density of the distribution lies and the scattered rain of all the individual data points [4]. The colored lines highlight the mean differences between the intervention groups. Figure 3 is complemented by Table 2 which also shows the sample size, mean and standard deviation from each intervention group after the log transformation. Table 2 also highlights that we were not in complete control to enforce the newsfeed diets. We captured partial data on the percentage of unfollowed contacts which suggests that the unfollow procedure was not completed by all users in the field experiment. This refers to average and median percentage changes in followed contacts between baseline and treatment periods for each newsfeed diet.

Table 1: Descriptive statistics across each newsfeed diet intervention group during the baseline period of the field experiment

	Control				Text Strict diet				Self-regulated diet			
Variable	$\hat{m}$	$\hat{\mu}$	$\hat{\sigma}$	n	$\hat{m}$	$\hat{\mu}$	$\hat{\sigma}$	n	$\hat{m}$	$\hat{\mu}$	$\hat{\sigma}$	n
Time on site/app (s)	1385.9	2044.6	2650.1	42	1594.7	2087.5	2020.2	49	1090.3	2279.9	3069.9	47
Compulsive Use	3.750	3.953	1.384	43	3.625	3.730	1.350	50	3.250	3.702	1.910	47
SUS score	80.00	80.23	14.19	43	75.00	73.50	18.70	50	80.00	78.03	13.61	47
Age	29.0	31.05	10.51	43	28.0	31.28	11.95	50	24.0	26.89	7.98	47
Gender (% female)		65.12		43		58.00		50		63.30		47

EmPure Comment:
Mean >> Median indicates that some users are outliers who spend very substantial time on platforms well above the average user. These are the Facebook addicts who skew the data.

The red box should be 100% for a strict diet. This indicates some cheating by strict dieters (non-compliance) by refollowing without permission. Apparently, Facebook is so addictive that some of those in the study couldn't stand three weeks without some manual refollowing. The authors acknowledge this deficiency in the study in the green highlighted text on the prior page.

Table 2: Log transformed time on site/app measures for the baseline and treatment periods across each newsfeed diet intervention. Missing values in the percentage change of followed contacts across each newsfeed diet: No diet: 16, Strict diet: 19; Self-regulated diet: 24

	Baseline period			Treatment period			% Change in followed contacts	
Newsfeed intervention	n	$\hat{\mu}$	$\hat{\sigma}$	n	$\hat{\mu}$	$\hat{\sigma}$	average	median
No diet	41	7.040	1.220	41	7.039	1.515	↓ 3.3	↓ 0.0
Strict diet	47	7.175	1.174	47	6.157	1.544	↓ 62.0	↓ 82.7
Self-regulated diet	46	7.006	1.309	46	6.489	1.560	↓ 65.1	↓ 77.4

Table 2 highlights large differences between the control and the newsfeed diets, but not between the two newsfeed diets. We also computed the log changes in time on site/app between the baseline and treatment periods. These log changes are visualized again with raincloud plots in Figure 3 D). The untransformed changes in daily time on site/app across each newsfeed diet group can be found in Figure 3 C). The connection between the raincloud plots in Figure 3 is the following: The distribution curves, boxplots and scattered rain shown in C) are simply the result of subtracting the baseline week data from the treatment week data in plot A).

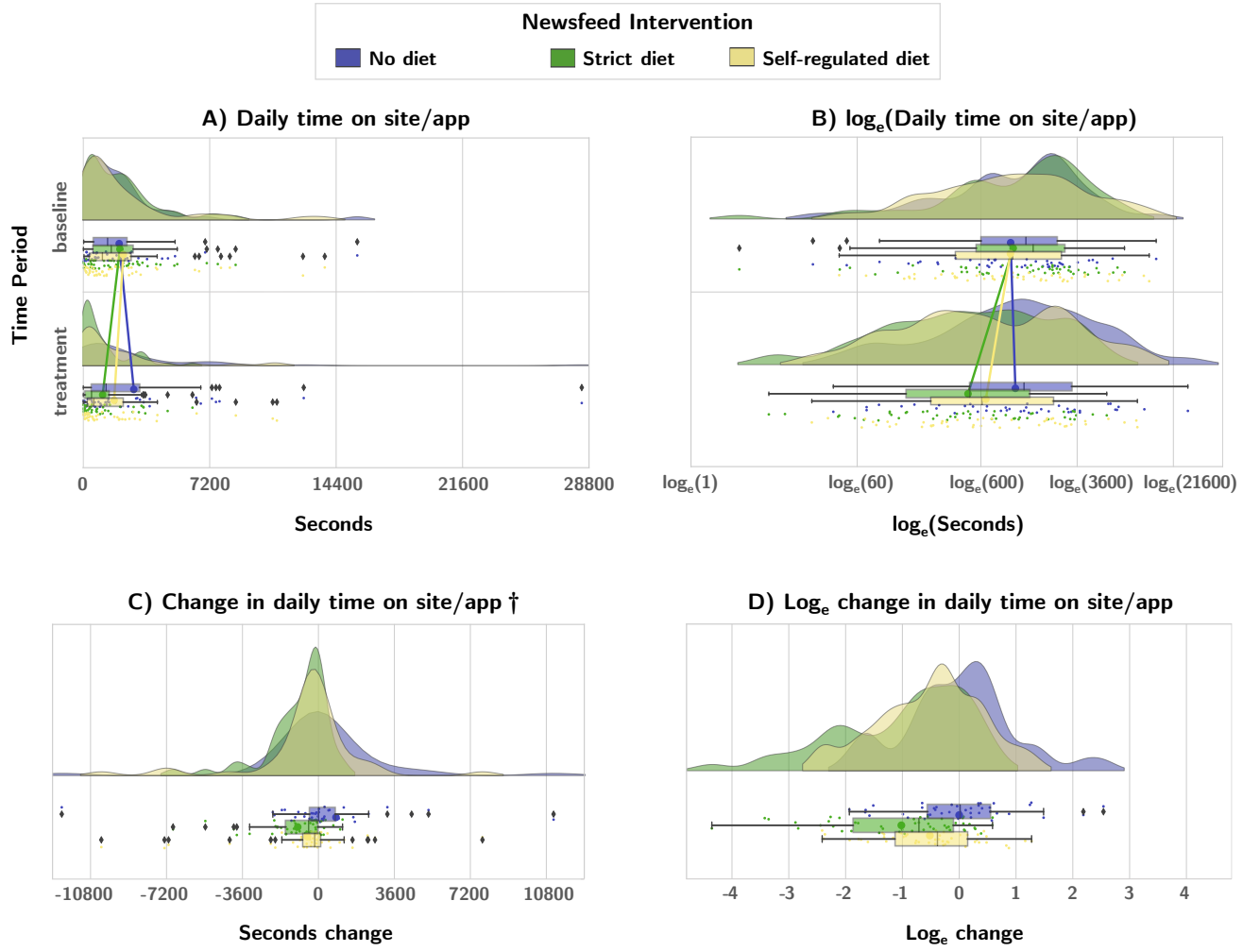

Figure 3: Raincloud plots [3] A) and B) showing time on site/app across each newsfeed diet during baseline and treatment weeks together with C) and D) showing changes in time on site/app between baseline/treatment weeks across each newsfeed diet. † The x-axis of this raincloud plot excludes one outlier at +26145 seconds that can been seen at +2.539 in raincloud plot D)

26,145 seconds per day is over 7 hours per day for a three week study.
This person is a Facebook addict and needs intervention from EmPure software.

With the log transformed data in Figure 3 B), the same subtraction is performed which results in plot D).

To examine the change that the newsfeed diets may have had on time on site/app and to investigate whether restricting the newsfeed had a different impact on users who need it most, i.e., compulsive users, we specified three multiple regression models in a hierarchical fashion. In each model, we regressed the log changes in time on site/app between the baseline and treatment periods on a number of predictors. The dependent variable used for these models is visualized in raincloud plot D) in Figure 3. This dependent variable is the natural log change in time spent on site/app between the treatment and baseline periods. In the first model, we simply introduce the two newsfeed diets as dummy variables with indicator coding. This model is related to H2a and H2b.

In the second model we do the same while also adding users' logged baseline measures for time on the site/app together with their compulsive use measure before the baseline period. The second model therefore accounts for the potential effect from the interventions and compulsive use, and with the fact that different users spent different amounts of time on Facebook during the baseline period. This is sometimes referred to as a conditional change model [2].

In the third model we keep the previous predictors while also introducing the moderating effects of compulsive use during the baseline period on each intervention group e.g. d_1x_2 and d_2x_2. This model relates to H3. The Appendix contains a description of all variables used in the three regression models. The results of the first model in Table 3 show that the strict newsfeed diet is a significant predictor of log change ($p < 0.005$) whereas the self-regulated diet intervention is a suggestive predictor ($p < 0.05$). These predicted changes mirror the descriptive results seen in Table 2 and raincloud plot D) in Figure 3, while controlling for the effects of the other intervention. The first model suggests that if a user was in the strict newsfeed diet group (while controlling for the effect of the self-regulated newsfeed diet) their change in time on Facebook's site/app between the baseline and treatment periods was $(\exp(\beta_1) - 1) * 100 \approx -63.868\%$.[3] H2a is supported.

If a user was in the self-regulated diet group (controlling for the effects of the other group) their change in time on site/app between the baseline and treatment periods will be approximately $(\exp(\beta_2) - 1) * 100 \approx -40.310\%$. H2b is has suggestive support. The results of the second model indicate that the interventions remain stable predictors of log changes in time spent on the platform when controlling for the users users' logged baseline measures for time on the site/app and their standardized compulsive use before the baseline period. The increase in explained variance (Adj. R^2) between the first and second models is non-significant: R^2-change .026, F-change $(2, 129) = 1.983, p = 0.142$. That is, users' time on site/app during the baseline period and their level of compulsive use only explains an additional 2.6% of changes in time on the platform when we have already controlled for the effects of the two newsfeed diets. Also, the second model shows that neither the users' time on

[3]These percentage changes in time on site/app refer to the natural log transformed space. As a reference point, the untransformed median percentage changes in time on site/app between the baseline and treatment weeks for each newsfeed diet are approximately: No diet: −6%; Strict diet: −70%; Self-regulated diet: −45%.

Table 3: Multiple linear regression models: Predictors for log changes in time on site/app between baseline and treatment periods

		Regression coefficients						
Model	Variable	$\widehat{\beta}$	95% CI	Std. Error	t	VIF-value	p-value	Adj. R^2
1	Constant (β_0)	0.001	[-0.320, 0.319]	0.161	-0.005		.996	.126
	Strict diet	-1.018	[-1.455, -0.581]	0.221	-4.606	1.394	.000***	
	Self-regulated diet	-0.516	[-0.955, 0.077]	0.222	-2.323	1.394	.022*	
2	Constant (β_0)	0.008	[-0.326, 0.310]	0.161	-0.050		.960	.139
	Strict diet	-0.982	[-1.417, -0.546]	0.220	-4.460	1.403	.000***	
	Self-regulated diet	-0.498	[-0.935, -0.061]	0.221	-2.257	1.398	.026*	
	† $\log_e$(Time on site/app)	-0.129	[-0.287, 0.028]	0.080	-1.624	1.208	.107	
	Z-score Compulsive Use	0.171	[-0.025, 0.362]	0.098	1.719	1.208	.088	
3	Constant (β_0)	0.001	[-0.319, 0.322]	0.162	0.009		.993	.134
	Strict diet	-0.989	[-1.427, -0.551]	0.221	-4.471	1.409	.000***	
	Self-regulated diet	-0.509	[-0.948, -0.070]	0.222	-2.293	1.403	.024*	
	† $\log_e$(Time on site/app)	-0.129	[-0.288, 0.029]	0.080	-1.619	1.211	.108	
	Z-score Compulsive Use	0.073	[-0.292, 0.439]	0.185	0.398	4.260	.691	
	Strict diet x Compulsive Use	0.262	[-0.245, 0.769]	0.256	1.024	2.003	.308	
	Self-regulated diet x Compulsive Use	0.060	[-0.376, 0.496]	0.220	0.273	3.098	.785	

* $p < 0.05$, ** $p < 0.005$, *** $p < 0.001$

Model 1: $\log_e(\frac{y_1}{y_0}) = \beta_0 + \beta_1 d_1 + \beta_2 d_2 + e$

Model 2: $\log_e(\frac{y_1}{y_0}) = \beta_0 + \beta_1 d_1 + \beta_2 d_2 + \beta_3 \log_e(x_1) + \beta_4 x_2 + e$

Model 3: $\log_e(\frac{y_1}{y_0}) = \beta_0 + \beta_1 d_1 + \beta_2 d_2 + \beta_3 \log_e(x_1) + \beta_4 x_2 + \beta_5 d_1 x_2 + \beta_6 d_2 x_2 + e$

† Refers to the baseline period, to aid interpretation this variable has been centered $(x_i - \bar{x})$

site/app during the baseline period nor their level of compulsive use are suggestive predictors of log changes in time on site/app, see Table 3. So while compulsive use has a strong association to average daily time on site/app during the baseline period, it is not a strong predictor of *changes* in time on site/app between the baseline and treatment periods when controlling for the other predictors.

Lastly, the results of the third model assess if the log changes in time on site/app for each standard deviation increase in compulsive use is significantly different between users who are in the intervention groups (while controlling for the previously mentioned effects in the first and second). As Table 3 shows, the moderating effects of compulsive use on the strict and the self-regulated newsfeed diet add basically no explanatory value to the third model: R^2-change .008, F-change $(2, 127) = 0.603, p = 0.549$. The regression coefficients for the interaction terms $\hat{\beta}_5 = 0.262, p = 0.308$, $\hat{\beta}_6 = 0.060, p = 0.785$ respectively, are not suggestive predictors of change in time on site/app. In fact, the proportion of explained variance goes down between the second and third models. These moderation effects (or lack thereof) suggest that the efficacy of the two newsfeed diets are not impacted by more and less compulsive users. H3 is not supported.

5.3 Effects of restricting the newsfeed on user experience (H4a, H4b)

To investigate H4a and H4b we coded and analyzed the answers for the SUS questionnaire and the open usability questions, for which 140 users provided answers (367 comments, 6608 words). The SUS score, which focuses on the ease of use of Facebook did not change significantly between the baseline and the treatment periods. The answers to the open questions were coded line by line by two of the co-authors based on the negativity of the emotions related to the usability, such as negative sentiment, hate, frustration, boredom or annoyance about missing important information. For instance, the following answer was coded as negative: "*It was annoying not getting updates from friends, but particularly from my groups – I was actually trying to sell and give away some items in some groups and I had to find the notifications and information and messages manually!*"

To validate the codes, we measured inter-rater reliability [32]. The two coders agreed on 135 ratings and disagreed on 5. That translates to 96.4% agreement which is above 75% and hence considered acceptable [83]. The coders discussed the disagreements to reach a consensus. The results show a proportion of negative comments of 23.3% in the control group, 21.2% in the self-regulated diet group and 56% in the strict diet group. The chi-square test of independence showed that the proportion of users reporting negative comments differed significantly between the newsfeed interventions $\chi^2(2, n = 140) = 16.316$, $p < 0.001$. Additional χ^2tests showed that users in the strict newsfeed diet condition reported a significantly more negative user experience than the control condition $\chi^2(1, n = 93) = 10.258$, $p < 0.001$ and users in the self-regulated diet group reported significantly less negative user experience than the strict newsfeed diet condition $\chi^2(1, n = 97) = 12.259$, $p < 0.001$. These results are supportive of H4a and H4b.

The content of the negative comments was different between newsfeed diet groups. In the control group, with no diet, some users had the impression that the extension that they installed affected their user experience of Facebook, even though the extension was not active in this condition. Consequently, most negative comments in this condition mentioned unspecific effects such as: "*Your feed can get a bit boring*", "*Feeling anxious about maybe missing out on something important*", "*Feeling like you missed out*", "*When I opened Facebook it would show a lot of white at first. It worried me what I would miss.*" In the strict newsfeed diet, in contrast, the negative comments mentioned specific effects such as "*It was annoying that there was absolutely nothing left on my Facebook feed*", "*I actually missed out on some key things referenced by friends in conversation mentioned on Facebook*", "*It unfollowed some people and caused me to miss some important posts.*" The negative comments of the self-regulated diet condition were overall similar in tone to the strict newsfeed diet condition such as: "*I lost everyone who I enjoyed following*" or "*I wasn't able to keep up with any of my family or friends that live far away.*"

6 EXPLORATORY THEMATIC ANALYSIS

To go beyond the hypothesis we tested in Section 5 and to broaden the analysis of the user experience, we conducted an exploratory thematic analysis [12, 72] of the three open usability questions about their positive, negative and overall user experience. We first established reliable codes for user experience and then used those codes to generate themes representing shared meaning. We used an inductive and deductive hybrid approach [23]. Deductive codes were developed such as disconnect, mindfulness and autonomy, to name a few based on previous research on user experience that we reviewed in Section 2. Inductive codes were added after reviewing the data. Then we iteratively coded the 140 responses over a period of one week. During our coding, we focused on responses indicating user experience. We excluded several responses that did not relate to user experience but rather referred to some technical glitches during the experiment that participants experienced such as, "*I want to say that I messed up when creating a shortcut when I close Facebook on my iPhone. I rechecked my mistake and saw that the file path was the same as /Open.csv. I am sorry for my mistake.*" Also, the responses such as "*study was fine*" and "*I think it was well done*" were also not taken into account. The process of coding was done by two researchers independently. The researchers then came together to share their independent analysis, which was discussed, and relevant themes were generated. In total, six main themes emerged and are discussed in the following section: fear of missing out (FOMO), focus, self-awareness, ease-of-use, sense of control and liberation. These results are summarized in Table 4.

6.1 Fear of missing out (FOMO)

FOMO is having a persistent fear that others may be having rewarding experiences while one is deprived [82]. More precisely, it is people's fear of missing out on experiences across their extended social network. The users in the field experiment experienced the fear of missing out despite knowing that they could contact their friends via messages on Facebook. This suggests that these relationships can quite passive or dormant on Facebook. The responses such as "*Feeling anxious about maybe missing out on something important*" were coded as "*missing*". One user reported that they actually missed out on an important event: "*I missed my friend's memorial*

service because I did not see the posts about her death." It also came to light that participants used Facebook to track the wellbeing of their friends and family: "*I would miss out on important things that are happening with friends and family.*" In the strict newsfeed diet a participant mentioned, "*But I did find myself wondering quite often what I might be missing. I worried particularly about missing some important news in my friends' lives.*" Not just the feeling of missing out but the feeling of being judged by others also emerged: "*I was worried people thought I was ignoring them or didn't care about what was happening in their lives.*" Figure 4 suggests that the members of the self-regulated diet were less likely to worry about missing out than those in the strict group, yet they reported that they received fewer posts on their newsfeed from their friends and family than they had expected: "*It doesn't update with new things that you've followed often enough.*" In Figure 4, the FOMO theme emerged about twice as often for users in the strict diet compared to the other newsfeed diets. Figure 4 also highlights that there is a suggestive association between the occurrence of this theme and the newsfeed interventions ($\chi^2 = 6.356$, $V = 0.213$, $p = 0.042$). As an interesting side note, some users in the control group reported seeing fewer posts after installing the chrome extension, despite no changes on their newsfeed being made by the extension.

6.2 Focus

In our analysis we consider focus to be a state when individuals are able to direct their attention to meaningful activities without being distracted. Previous studies suggest that users are often preoccupied with distractions, which leads to difficulties focusing their attention on other tasks [55, 74]. The responses such as "*my Facebook experience became more wholesome overall*" were coded "*UX improved*". While the responses that referred to the improvement of their ability to focus, such as "*it cleared my Facebook newsfeed of post and pictures I didn't want to see, which I really liked. Ever since downloading the extension I see more relevant and important things on Facebook*" were coded as "*declutter*".

Our analysis indicates that individuals were able to focus on tasks after cleaning their newsfeed. For instance, some individuals felt that the newsfeed intervention helped them to focus by removing distractions, while keeping relevant content on their newsfeed, (e.g., "*The best thing is that it can help reset your Facebook feed, and by that I mean that it can help clear your Facebook feed so that you can go back and choose what you want to see everyday. It can help declutter your feed*"). A user from the self-regulated diet reported increased ability to focus on other tasks: "there was

Table 4: Main themes and their codes from the thematic analysis with representative quotes from each newsfeed intervention.

Main themes	Associated codes	Representative quotes related to each newsfeed intervention
FOMO	missing, anxious, missed information, fewer connections, less content, disconnection	*No diet:* "Feeling like you missed out" *Strict diet:* "I was not updated about anything on Facebook" *Self reg diet:* "Not being able to see a lot of content on Facebook, only seeing the same content over and over"
Focus	declutter, less notifications, reduced distraction, time for other tasks, UX improved	*No diet:* "Seeing fewer notifications" *Strict diet:* "Focus on my work and accomplish what i needed to" *Self reg diet:* "It allowed me to selectively follow and focus on posts that I really care about. When choosing people to re-follow I found there are a lot of people I don't really care to follow. I also didn't feel guilty because I knew that they wouldn't know I wasn't following them"
Self-awareness	less time-spent, behavior change, increased consciousness, mindful	*No diet:* "The mental clarity it provides" *Strict diet:* "In a way helped me to see exactly how much time I inadvertently spent on Facebook and how often I went on there" *Self reg diet:* "I have decided to reduce my time using social media. Also, I removed all of them from my phone 2 days ago. This survey probably led to big changes in my life and I hope it will change my life for better"
Ease-of-use	automation, effortless, painless, automatic	*No diet:* "I was expecting it to feel a lot more intrusive but it wasn't" *Strict diet:* "The best thing about the extension is that it does everything for you automatically" *Self reg diet:* "It is very hidden and does not interfere with my actions"
Sense of control	manage newsfeed, ability to control, capability, autonomy	*No diet:* "It gives you more power to control what you see and don't see on your Facebook feed, which could make your experience more positive. Things that irritate you will not irritate you anymore" *Strict diet:* "Now I can choose what I actually care about to pay attention to" *Self reg diet:* "It makes you deliberately decide who to re-follow and what fits your interest"
Liberation	stopped using Facebook, reduced desire, reduced motivation	*No diet:* "It more or less will defeat the purpose of continuing to have a Facebook account. You might as well either not log on or deactivate your account" *Strict diet:* "Not seeing my feed on Facebook for 2 weeks convinced me that I really don't need Facebook anymore" *Self reg diet:* "There's no point in checking it"

more time to complete other tasks." Likewise, another user reported that the unfollow process has enabled focusing on spending more time with family members: *"I felt slightly disconnected from others but it was kind of good because I spent more time with my family than scrolling Facebook."* Not only did users report reduction in distractions but they indicated that the posts on Facebook newsfeed had become more relevant, allowing them to focus on relevant posts: "*ever since downloading the extension I see more relevant and important things on Facebook.*" Figure 4 highlights that users in the self-regulated diet condition reported often that cleaning the newsfeed has led to a decreased number of notifications that usually leads to distraction: "*the best part is not being overwhelmed with several notifications*". Figure 4 describes a more frequent occurrence of "*focus*" as a theme in the self-regulated newsfeed compared to the other two groups. However, there was no suggestive association between the occurrence of this theme and the different newsfeed diets (χ^2 = 4.387, V = 0.177, p = 0.112).

6.3 Self-awareness

Our study referred to the following definition of self-awareness: the ability to reflect and evaluate oneself objectively through introspection [45]. Most often, individuals open the app unconsciously after a certain period of time, eventually leading to automatic behaviors of checking social media regularly and not being mindful of their habit [8, 25]. When participants reported several responses such as the following "*in a way helped me to see exactly how much time I inadvertently spent on Facebook and how often I went on there*" we coded them as "increased consciousness." Some comments suggested that the participants began to get out of the habit loop of opening Facebook often, especially the users in the strict diet group: "*After a while I just got out of the habit of checking Facebook on my laptop*". Moreover, many participants became self-aware that spending time on Facebook was not the best allocation of their time: "*Not seeing my feed on Facebook for 2 weeks convinced me that I really don't need Facebook anymore and that's a good thing*". Also, the reason behind the participants' increased Facebook use came to light as individuals' Facebook feed became more empty and decluttered: "*Interesting to see how often I look to Facebook to relieve boredom.*" The participants in the self-regulated diet group often reported that they decreased the time they spent on Facebook: "*it caused me to spend less time on Facebook*" and the intervention made them realize that they do not need Facebook: "*I found that I don't need Facebook overall, and this study helped me figure that out.*" While the only difference between self-regulated and strict diets was that participants in the strict diet were forbidden from following their friends, pages and groups, the theme of self-awareness emerged more often among those on the strict newsfeed diet compared to the other diets, as shown in Figure 4. There is also a suggestive association between the occurrence of this theme and the newsfeed interventions (χ^2 = 6.888, V = 0.222, p = 0.032).

6.4 Ease-of-use

In previous research, it was found that platforms with fewer frictions or interruptions and greater ease of use improve user experience [18]. Our analysis followed previous research and deemed reduced effort an indicator of ease of use. Users generally did not need to put a lot of effort into unfollowing their contacts. Several participants emphasized "*ease-of-use*" which is an essential component of usability. The responses such as "*I appreciate how the extension has the ability to automatically unfollow friends, pages, and groups*" were as coded as "*effortless.*" The users appreciated the ease-of-use of the intervention as it worked in the background, and individuals did not have to manually unfollow any of the friends, pages and groups: "*I like that it automatically unfollowed pages for me since I followed a lot of them.*" Furthermore, users appreciated that extension does not interfere with their other Facebook activities: "*It is very hidden and does not interfere with my actions.*" A code that kept recurring in the strict diet condition was automated: "*The best thing about the extension is that it does everything for you automatically.*" The difference between the interventions regarding how many times their responses came under the theme related to ease-of-use is non-significant, as seen in Figure 4, (χ^2 = 0.883, V = 0.079, p = 0.643).

6.5 Sense of control

Sense of control is a psychological phenomenon that occurs when individuals feel that their actions and consequences are under their control, i.e., they feel that they are in the driving seat [63]. The newsfeed diets seemed to instill in users a feeling of autonomy and control. The idea of automating the unfollowing of contacts that

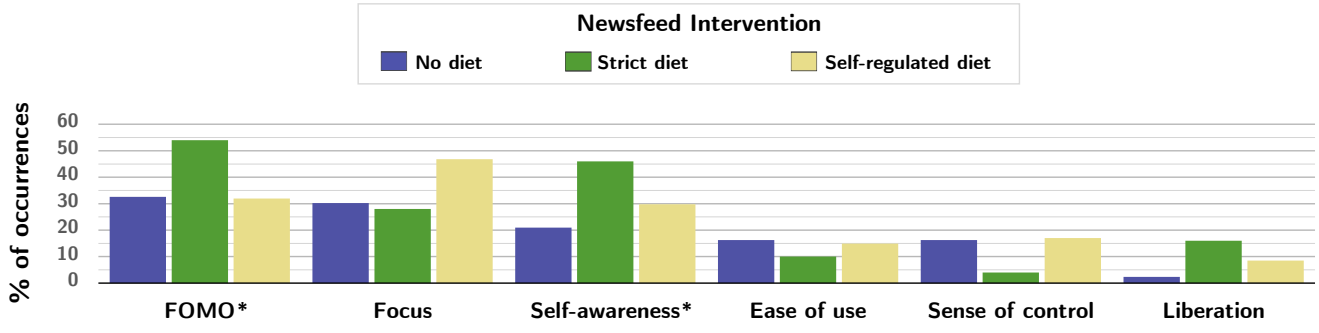

Figure 4: Percentage of users in a given newsfeed intervention group who mentioned a given theme. χ^2 tests were conducted to test the likelihood of occurrence of a given theme across the interventions ($2, n = 140$), * p<0.05, ** p<0.005, *** p<0.001. These tests were performed without using a family-wise error correction, i.e., ($\alpha_E/1$)

users have been following by default and then allowing them to choose which friends, pages and groups to follow increased their sense of agency and control on Facebook: "*the best thing is that it can help reset your Facebook feed, and by that I mean that it can help clear your Facebook feed so that you can go back and choose what you want to see everyday.*" Another user from the self-regulated diet reported that, "*It allows me to have control over my Facebook account. I enjoy the overall user friendly interface and design.*" Responses of this kind indicate that when the sense of agency increases, the user experience may be enhanced. One user mentioned the following: "*It allowed me to selectively follow people I really care about. When choosing people to re-follow I found there are a lot of people I don't really care to follow. I also didn't feel guilty because I knew that they wouldn't know I wasn't following them.*" It is important to mention that Facebook's UI already gives users the option to selectively follow contacts they really care about. As we mentioned in the section on related work, this option exists on Facebook, but can be difficult for users to discover.

In Figure 4, we also observe that users in the strict diet condition did not feel as much of a sense of agency or control as those in the self-regulated condition. That said, there was no suggestive association between the newsfeed diets and the occurrence of this particular theme (χ^2 = 4.846, V = 0.186, p = 0.089).

6.6 Liberation

When individuals are able to put an end to their dependence on a certain activity or pattern, they feel liberated [69]. With regard to Facebook use, liberation is when individuals lose their desire or motivation to use Facebook, which they had been captivated by. Several users reported a sense of liberation as their motivation to use Facebook declined over the course of the field experiment. Few users in the self-regulated diet reported a loss of motivation and desire to use Facebook, see Figure 4.

The users in the strict diet condition reported more frequently that their motivation and desire had taken a hit: "*I am less motivated to use Facebook when I should be doing something else, like working or studying.*" As one user reported, the lack of motivation and desire also led them to question their need for the service itself: "*Not seeing my feed on Facebook for 2 weeks convinced me that I really don't need Facebook anymore.*" Sometimes users in the strict diet reported that the resulting friction around the access to posts and information as something positive: "*The best thing about the app is it really removed my desire to go onto Facebook. I couldn't easily see posts or information from any of my friends, so I didn't feel very motivated to check the site at all.*" However, we saw no suggestive association between the newsfeed diets and the occurrence of liberation as a theme (χ^2 = 5.182, F = 5.012, p = 0.076)[4].

7 DISCUSSION

The present paper investigated the effects of a novel automated digital unfollow intervention that restricted and practically reduced the content of individuals' newsfeed by unfollowing the users' friends, pages and groups. We conducted a field experiment with real Facebook users randomly assigned to one of three independent conditions: the control condition (no diet), a strict newsfeed diet and a self-regulated newsfeed diet. Unlike other digital wellbeing research that focuses on external interventions such as timers [1], overlays, feedback [66] and limits [44], we focused on changing the internal choice architecture of the platform itself. We structure the following three subsections by laying out first our contribution, and we close the subsections with the implications to the relevant stakeholders.

7.1 Newsfeed diet interventions

Our results show that users reduce their Facebook use just due to the restriction or reduction of their newsfeed. We observe that a strict newsfeed diet is a significant predictor of change in time on site/app (H2a) by around -64%. Understanding exactly how individual design mechanisms translate into more or less usage of a social media app is difficult owing to the subtle nuances in the design space of previous interventions. The results of a previous study that related to the Facebook accounts of several US police departments indicate that posts containing UI elements such as links and images translate into more likes and interaction from users [85]. This suggests that if such UI elements are limited upstream (e.g., by a newsfeed diet) then users would spend less time on the platform itself. However, previous research results related to filtering or blocking the newsfeed are mixed. As we mentioned in the section on related work, Lyngs et al. conducted a user experiment where one of the interventions was a completely hidden/blocked newsfeed [55]. This newsfeed blocking intervention did decrease users' visit length on Facebook's site with FOMO being a major theme among the users. While we did not use visit length as a dependent measure, our overall results are quite well in line with those findings. Another study found no significant differences in usage time when introducing a feed filter on Twitter [86]. However, this feature was partially responsible for increasing users' sense of agency on the platform itself. In the strict condition, we observed that the drop in time on site/app was happened in parallel to more frequent reporting of negative user experiences, as measured by negative emotions (H4a). Yet, our thematic analysis provides a more mixed picture of this result where users in the strict condition more frequently express rather positive themes such as liberation and self-awareness. These results indicate that such a drastic intervention may be effective at reducing time spent on Facebook, but is not satisfactory from a user perspective. This result is also in line with previous studies that have underlined that more restrictive mechanisms cause more frustration among the users [40, 55]. Previous design researchers have attributed this reaction to the diversity of usage contexts and user needs [40, 53].

In addition to these observations, we also found that the self-regulated newsfeed diet had a suggestive decrease in time on site/app (H2b) by around 40%. Furthermore, our findings indicate that this type of intervention is associated with a more positive user experience as compared to the strict newsfeed diet condition (H4b). Indeed, over half of the comments in the strict diet condition reported negative feelings compared to only around one in five in the control and the self-regulated diet conditions. This is a novel contribution to the field, which indicates that not only complete abstinence but also limitation of the number of content providers of the newsfeed may reduce time spent on the platform while enhancing users'

[4] F refers to Fisher–Freeman–Halton's Exact test statistic as the cell count for this particular theme is < 5 for the No Diet intervention

experience compared to more strict abstinence. Looking in more details at the user experience, our thematic analysis provides a first tentative explanation that such a self-regulated diet helps users to avoid distractions and to focus on the useful interactions that a social media newsfeed can provide.

Future research could further explore the mechanisms through which modifications in the newsfeed affect user experience and time on site. For instance, our research cannot answer questions about whether the observed effect is due to the number of connections unfollowed, the type of connections unfollowed or the type of content that appeared in the newsfeed itself. In a nutshell, these questions relate to the social graph architecture which connects nodes (users), through edges (follow relationships), on which messages (content) can be passed. This leads to future research questions such as how do social graph architecture components affect time on site and user experience?

Also, future research could further investigate the value provided to users by different types of connections. Our thematic analysis related to FOMO provides some preliminary indications that users valued interaction with friends and family, which aligns with some previous findings [51, 70]. Future research could, however, formally confirm whether that value enhances user experience.

7.1.1 Implication for designers. Our results suggest that the current newsfeed design might work as expected by social media platforms: it increases time spent on site compared to more curated versions. In this regard, social media platforms have little direct incentive to give users the tools to easily unfollow those connections that are less interesting to them. However, approaches that increase user benefits at the expense of time spent on the platform (resulting in potential short-term revenue decline from advertising) could give longer-term benefits to the platform, such as increased loyalty, increased brand image and less regulatory scrutiny. Furthermore, potential FOMO associated with cutting ties with updates from friends and family might indicate that social media companies could build on these connections rather than on unconnected content updates, which seems to be a current trend. Recent reports suggest that Facebook will modify the platform's newsfeed feature to focus more on "*unconnected*" content sources in an effort to compete with TikTok [33, 64]. Finally, from the perspective of designers of apps, those plug-ins or extensions that help users spend less time on social media or at least help them regain control over their time on social media may target the newsfeed to effectively intervene in the platform. Removing the newsfeed or limiting its content are useful tools in that respect.

7.2 Understanding compulsive use

In our research, and contrary to what we predicted, different levels of compulsive use did not moderate the effectiveness of our interventions (H3). These results are surprising, since they contradict what could have been predicted based on previous literature on habits [84]. Nevertheless, the results seem to confirm more recent literature on closely related digital wellbeing interventions [53]. This is an interesting prospect, showing that digital interventions can curb Facebook use even for compulsive users. Our thematic analysis hints at potential novel mechanisms explaining the impact of that type of digital interventions on time on site. For instance, the strict diet intervention could increase users' self-awareness, which allows them to reflect on their behavior as well as to decrease the motivation to go online due to a potentially less rich user experience. According to our data, these mechanisms would be operating irrespective of the user's level of compulsive use.

In addition, previous scholars have argued for more comprehensive research into the underlying mechanisms that may influence users' compulsive behavior on social media platforms [80]. In this respect, our study contributes to quantifying the antecedent of users' compulsive use. We have investigated the association between the time spent on Facebook's site/app and compulsive use (H1). Our data suggests a clear statistical relationship between time on Facebook and self-rated compulsive use. However, the Pearson correlation between compulsive use and log transformed time on site/app results in a coefficient of determination of ($0.388^2 = 0.151$). That is, only about 15% of the variation in compulsive use is explained by its relationship with time on site/app. This means that roughly 85% is still unexplained. In other words, there are several other relevant factors that are associated with compulsive use.

Future research could allocate more attention to the effect of newsfeed (and more broadly digital) interventions on compulsive users. One such research direction could further dissect time spent on site/app as the measure itself might not be enough to account for digital wellbeing [86]. The type of interaction and the context of the interaction could be further explored. Also, it could be useful to look in more details at cases at the margin, such as high use but low compulsion or high compulsion but low use, which could shed further light on how to best design social media-like interactions in the interest of users. Furthermore, although we show that 15% of the variation in compulsive use is explained by its relationship with time on site/app, we do not know how a decrease in time on site/app affects the level of compulsiveness.

7.2.1 Implication for designers. The major implication is that newsfeed modifications can significantly affect the time on site/app of compulsive users and, as a result, serve as a potential tool to increase digital wellbeing. Furthermore, policy designers who are currently interested in curbing dark patterns online [49] could leverage our results to push for better support for compulsive users and push social media companies for more accountability on this matter.

7.3 Designing for agency

Previous HCI researchers have demonstrated the importance of users feeling in control of their interaction with social media platforms [51, 55, 86]. As described in cognitive neuroscience, control refers to being in charge of one's own actions and affecting the external environment through that control [17]. Through years of scientific research and testing, it has been demonstrated that a positive user experience is associated with a sense of agency [73]. Indeed, a recent study showed that users are willing to have more options. For instance, one user reported "*I wish there could be some kind of middle ground. Like a feed with only my best friends and favorite pages?*" [70]. To further support the statement, a study by Lyngs et al., [55] found that most participants expressed a desire for easy ways to filter, limit or disable newsfeeds.

Against this backdrop, our study provides a novel intervention to reduce use while giving users more control over their newsfeed.

Furthermore, the thematic analysis highlights that users in the self-regulated diet as well as in the no diet (control) condition, reported a sense of control that was mostly missing from users in the strict diet condition. As a result, while both interventions led to less time spent on Facebook, only the self-regulated diet reported a retained a sense of control that was similar to the no diet group. It should be noted that with current mainstream social media platforms, users could potentially implement such a self-regulated diet. However, as mentioned above, the default option which follows all contacts and forces users to explicitly opt-out works in a way that agency is reduced [76]. Future work could further investigate restrictions of the newsfeed while maintaining user agency. For instance, reversing the default in terms of following connections, from opting out to opting in, may give users more control. This would look like our self-regulated diet intervention, except that users would not have been exposed to the control (i.e., everyone followed by default) beforehand. Another possibility could be to follow by default close connections (e.g., start following users with whom there are messenger interactions), but not other types of connections. If needed, users could then follow other connections by themselves.

7.3.1 Implication for designers. Our findings suggest to designers of apps, plug-ins or extensions that whereas a strict diet might be more powerful, if followed by the users, it may trigger more reactance because of the freedom of restriction that it entails. In this case, users might more easily abandon it than they would with a self-regulated diet. Facebook and social media platforms seem to have limited incentives to give users agency in a way that would reduce their time on site. However, policymakers (e.g., regulators) could give users more agency by ensuring that they have the possibility to implement their intentions on the platforms that they are using. This is what the GDPR offers with the prohibition of the opt-out policy. Closer to our context, the regulator could enforce a principle of fair and symmetric frictions in user choice. If following all friends on a platform like Facebook is easy and friction-less (because it is the default option), unfollowing all friends could be made as easy as one click, in order to let users re-follow just their few important connections. Such a design principle could have broader reach than just the newsfeed. For instance, if creating an account needs two clicks, regulation could force the platform to allow the removal of users' account in two clicks.

7.4 Limitations

This study faces several limitations that could be addressed by future research. First, the Chrome extension's unfollowing procedure could take a long time depending on how many contacts users have. Consequently, the results suggest that some users in the strict unfollow condition did not fully unfollow all contacts as planned (the median percentage drop in followed contacts was 82% for this newsfeed diet). As such not all users in the strict diet had an empty newsfeed. Also, a given user's newsfeed could still potentially contain sponsored content even if all contacts are unfollowed. However, in the strict diet condition, even if the newsfeed was not empty for all users, no user could re-follow a contact in the browser. In this way, the fundamental difference in control over the newsfeed across conditions remained. Second, our data did not allow us to infer precise refollow behaviors. Identifying users' behaviors and attitudes behind the use of the newsfeed and further exploring who and why they chose to re-follow specific friends, pages and groups could have contributed to insights that would have been very helpful when designing for digital wellbeing in social media contexts. Third, our study only measured time on site/app on one particular social media platform, namely Facebook. We can therefore not assess whether the changes in time spent on Facebook was replaced by more time spent on other platforms such as Instagram or TikTok.

8 CONCLUSION

In this paper, we tackled the pressing issue of compulsive social media use. We took a design science approach to design a solution to reduce Facebook use specifically. Our solution – which consisted of reducing the endless newsfeed, breaking the relationship, called following, which makes a contact's updates spill over into the user's newsfeed – does indeed reduce the time spent on the platform, but it can have negative consequences in terms of usability. An alternative approach that lets users self-regulate their newsfeed diet suggests a decrease in time on the platform – without steep costs to the user experience. Our results also indicated that both of these approaches seemed to work for more compulsive as well as for less compulsive users.

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A APPENDIX

A.1 Multiple linear regression models

Variable descriptions in order of appearance for all three regression models in Table 3.

$\log_e(\frac{y_1}{y_0})$: Natural log difference in time spent on site/app between the treatment and baseline periods

d_1: Strict diet intervention as a dummy variable

d_2:Self-regulated diet intervention as a dummy variable

$\log_e(x_1)$: Natural logarithm of the daily average time spent on site/app during baseline period

x_2: Standardized compulsive use before the baseline period

d_1x_2: Interaction between standardized compulsive use before the baseline period and strict diet dummy

d_2x_2: Interaction between standardized compulsive use before the baseline period and self-regulated diet dummy

e: Residual