

# The Good, the Bad, and the Missing: Topic Modeling Analysis of User Feedback on Digital Wellbeing Features

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## Abstract

*Digital wellbeing features could potentially help users mitigate unintended effects of IT use such as smartphone addiction. However, knowledge about users' perceptions of such features is still scarce. To bridge this gap, we applied structural topic modeling to analyze user reviews of 93 digital wellbeing apps from the Google Play Store. Our findings revealed three promising research areas: (1) mitigation mechanisms associated with self-monitoring, goal advancement, and change UI features, (2) the relationship between restrictiveness of block features, user characteristics, and addiction levels, and (3) the association of gamification with other features to promote behavior change. We also highlight the advantages of using structural topic modeling to analyze a large body of app reviews. Finally, we provide developers of digital wellbeing apps with feature requests extracted from the reviews.*

## 1. Introduction

Smartphones offer many different functionalities to users. Although that makes peoples' lives easier, it can also create a dependence that results in unexpected side effects like addiction [1, 2]. Previous research has found smartphone addiction to have detrimental effects on individuals' professional and personal life [3]. Nevertheless, research that explores mechanisms to mitigate the negative effects of IT, especially at the individual level, is still scarce [4].

While substance addiction is regulated, means of IT addiction such as smartphones are not restricted [5]. As a result, individuals depend on self-regulation to control their usage time [2], which is a challenge due to the presence of addictive apps (e.g., social media) on their phones [6]. Tech companies such as Google and Apple have launched digital wellbeing apps to help users control their usage levels, and many other similar apps are available for download. Accordingly, digital wellbeing has attracted the interest of computer science [7] and information systems [8] researchers.

Digital wellbeing apps contain features such as self-monitoring, blocks, and gamification, which interact with users toward decreased smartphone usage in distinct ways. While previous research sought to uncover the features and their effectiveness [7], little is known about the features' effects on users [8], especially the adverse effects associated with their use [9, 10]. Thus, we propose the research questions: *What are users' opinions about digital wellbeing apps? How does the presence of specific digital wellbeing features in the app affect users' opinions?*

We applied structured topic modeling (STM) to discover relevant themes associated with users' opinions, and how the presence of specific features relates to the themes. With our findings, we contribute to theory and practice by highlighting future research areas, comparing the topics revealed with previous findings, and identifying existing gaps in current digital wellbeing features.

## 2. Background and Related Work

### 2.1. Addictive use of IT and smartphone addiction

While information technology has brought many benefits to the way individuals work, collaborate, and live, it is also associated with negative effects such as addiction [11]. IT addiction can be defined as "a user's psychological state of maladaptive dependency on IT use that is manifested through obsessive-compulsive seeking and use behaviors that compromise other activities" [12, p.321]. Given the adverse effects of IT addiction on individuals, organizations, and society [4], it is essential for IS scholars to engage in research about IT addiction mitigation [5]. However, there is a lack of research in IS on the consequences of using IT to help individuals overcome IT addiction [13].

Smartphone addiction happens when users interact with the applications that are present in their smartphones in a pathological way [1]. It is important to keep in mind that the artifacts (smartphone, computer) do not cause the addiction, they just enable

addictive behavior [3, 5]. Smartphone features associated with addictive behavior include speed, accessibility, convenience, design, efficiency, and portability [1], as well as notifications, feature-rich IT, interruptions, hedonic features, and changing content [10]. According to [14], IT addiction could be overcome when the user is helped by behavioral interventions, which have been found to help users decrease their smartphone usage [15]. Moreover, the use of technology to control unwanted habits seems promising [16, 17]. Thus, if properly designed, IT-enabled behavioral interventions could effectively help users to mitigate smartphone addiction.

## 2.2. Digital wellbeing features

Digital wellbeing apps are a bundle of digital wellbeing features that users can choose from to help their pursuit of physical and psychological wellbeing [8], usually by limiting device usage time [18]. [9, p.12] defines a digital wellbeing feature as “a feature of an IS that aims to improve the digital wellbeing of its intended recipient through various actions”. Table 1 shows the most common digital wellbeing features according to [7, 8, 19], namely self-monitoring, blocks, goal advancement, change UI appearance, gamification, and social support. Self-monitoring features track and display usage data (time, unlocks, notifications). Block features restrict use at the phone or app level. Goal advancement includes goal setting, reminders, motivational quotes, and comparison between goal and actual behavior. Change UI appearance features apply modifications to the UI, e.g., change the display to greyscale, to nudge users toward decrease usage. Gamification encompasses features such as badges, points, rewards, punishments, levels, or customization options. Finally, social support consist of features that promote comparison, competition, or support among users.

Even though there are many digital wellbeing apps available in the market and a growing number of researchers studying the effects of different interventions, research is still ongoing due to a lack of understanding of how such features work, which results in ineffective long-term solutions [7]. As a result, there is a lack of consensus among researchers as to which features a digital wellbeing app should include, or how the features should be designed [20].

One source of concern among researchers relates to the effectiveness of digital wellbeing features [7]. Previous research has suggested that features that enable the automation of self-control to support the formation of new habits might be more effective to help users decrease smartphone usage levels [16, 19, 21]. Further, an important driver of behavior change is users’ realization about their usage behavior [22], which can be triggered by self-monitoring features. Thus, understanding users’ perceptions regarding the effectiveness of the different features can inform researchers on the performance of such features.

Another issue raised by scholars involves the potential adverse effects of such features. For instance, [17] proposed design patters to increase effectiveness and minimize risks of discontinuance, e.g., variation and bundling of interventions, as well as intermediary control of which interventions are implemented. However, researchers and practitioners must consider the ethical implications of such design patterns. In this context, features that block access to the device or certain applications have been raising concerns, as they could desensitize users to manipulative prompts or be potentially used to increase control over workers [9]. Moreover, restrictive features that decrease the level of control over one’s device can be harmful to one’s autonomy, self-determination and wellbeing [23]. By uncovering users’ reviews on block features, it is possible to acquire insights into how aware and concerned users are of potential threats to their agency, as well as how users respond to this potential threat.

Furthermore, several digital wellbeing apps (e.g., *Forest*, *Study Bunny*) are making use of gamification features. Although such features are well liked by users [7] and support habit formation by promoting repetition [24], they might create a dependency on the feature, triggering further addictive behavior [10, 24]. As discussed by [23], interventions that aim to promote extrinsic motivation (such as the points and streaks used by gamification features) might only work in the short-term, impeding users from developing sustainable self-determination [23], which is promoted by intrinsic motivation and is essential for autonomy and performance [25]. However, combining gamification features with elements that support intrinsic motivation, e.g., letting users choose their

Table 1: Digital wellbeing features

Author	Feature classification								
[7]	<ul style="list-style-type: none"> <li>- block/removal: usage restriction</li> <li>- self-tracking: tracking and displaying usage information</li> <li>- goal-advancement: goal setting, goal reminder, motivational quotes, redirection of activities, behavior/goal comparison</li> <li>- reward/punishment feature: gain or lose points/streaks, praise/blame, social sharing, unlock achievements.</li> </ul>								
[8]	<ul style="list-style-type: none"> <li>Self-monitoring:               <ul style="list-style-type: none"> <li>- data tracking: unlocks, total usage time, app usage time</li> <li>- data presentation: summaries, charts, recaps, comparisons</li> </ul> </li> <li>Interventions:               <ul style="list-style-type: none"> <li>- phone and app-level timers</li> <li>- blockers</li> <li>- redesign of UI</li> <li>- extra features: motivational quotes, rewards, and automatic interventions</li> </ul> </li> </ul>								
[19]	<ul style="list-style-type: none"> <li>Core functionalities of digital wellbeing features:               <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">- visualization</td> <td style="width: 50%;">- tracking</td> </tr> <tr> <td>- blocking</td> <td>- negotiation</td> </tr> <tr> <td>- social comparison</td> <td>- change UI appearance</td> </tr> <tr> <td>- categorization</td> <td>- export</td> </tr> </table> </li> </ul>	- visualization	- tracking	- blocking	- negotiation	- social comparison	- change UI appearance	- categorization	- export
- visualization	- tracking								
- blocking	- negotiation								
- social comparison	- change UI appearance								
- categorization	- export								

own goals, might be a good alternative [26]. Thus, analyzing user reviews will enable an understanding of how they interact with gamification features.

Therefore, to reach a consensus regarding the design of effective and non-addictive digital wellbeing tools, it is important to know users' perceptions toward existing features. In this context, [7] conducted a content analysis of over 1000 user reviews from 42 digital wellbeing apps. The authors found that the majority of the reviews was positive, in which users mentioned different use cases, reported preferences, and described how the app can be used to control a series of unhealthy behaviors [7]. In contrast, they found negative reviews containing opinions about dislikes and usability issues, bug reports, demands for restrictive features, and privacy concerns [7]. Their results offer valuable insights into users' preferences, but there is still a lack of information about how the presence of specific features relates to user opinions and requests, especially when it comes to the aforementioned challenges. With these additional insights, we provide future research areas to advance research on digital wellbeing features.

### 3. Method

We analyzed user reviews using structural topic modeling, a text mining approach that has been used to understand online audiences [27], as it allows for a less resource-intensive analysis of large datasets in comparison to qualitative methods such as content analysis [28]. The analysis encompassed four main steps: data collection, data preprocessing, structural topic modeling analysis, and content analysis.

#### 3.1. Data collection and preprocessing

To select the apps, we ran searches on Google's Play Store for the keywords *digital wellbeing*, *screen time*, *focus mode*, *focus timer*, *digital detox*, *digital self-control*, *phone addiction*, and *digital diet*, which resulted in 256 apps. Then, we analyzed the app descriptions and selected those that met the following criteria: (1) the main goal of the app is to help users decrease their smartphone usage time; and (2) the app includes at least one digital wellbeing feature (self-monitoring, blocks, goal advancement, change UI appearance, gamification, or social support). That resulted in a set of 93 apps. Review data was collected using the *google-play-scraper* Python package [29], which was used to download all reviews written in English from the US region. The resulting dataset contained 147,266 written reviews.

Then, all reviews with fewer than 4 words or 40 characters were filtered out from the data, following

an approach previously used for analyzing Twitter data [30]. After filtering, 77,199 reviews remained. At this point, some non-English reviews remained in the data. These were filtered out using Python packages *langdetect* [31] and *langid* [32]. Emoji symbols and duplicate documents were also filtered out.

After these filtering steps, the remaining 74,705 documents were further processed with the R package *STM* [33]. Using the *STM* package's built-in processing function, all words were converted to lower case, punctuation, numbers and stopwords were removed, and the words were stemmed. As recommended by [30], only the words that were found in at least 5 reviews were included in the model.

#### 3.2. Structural Topic Modeling (analysis)

The structured topic model was created following the steps described by [33]. The following covariates were used: review scores, a spline function of the date of the review, the helpfulness score, and dummy variables for the digital wellbeing features.

Since the number of topics has to be chosen by the researcher, multiple models with varying number of topics must be created to find a suitable number of topics [33]. To choose the number of topics, we created models ranging from 5 up to 100 topics. All models were created with spectral initialization and seed 8458159, which is the seed used by [33] and that can be used for reproducing the results. To judge the quality of the models, we assessed their average semantic coherence and exclusivity [28, 33]. While semantic coherence reflects the co-occurrence of the most probable words close to each other across the texts (internal quality), exclusivity demonstrates whether a topic's top words appear in other topics as well (similarity between topics) [28]. Since both metrics should be as high as possible, a model in the upper right corner would be best. However, one must usually perform a trade-off between these two metrics when selecting the ideal number of topics. In our case, Figure 1 shows no number that dominates the other choices. When the number of topics is low, exclusivity increases rapidly when increasing the number of topics. This growth becomes minimal after 30 topics, while semantic coherence keeps declining. Thus, we chose 30 as the number of topics for the model. We also assessed model fit by performing a residual check. Large residuals can indicate that adding more topics might be able to absorb some of the variance [33, 34]. The residual plot (Figure 2) also shows 30 topics as the most viable option. After analyzing the statistics, we performed a content analysis of the topics in the various models. A larger number of topics often resulted in multiple similar

topics being part of the model, or in various topics that were hard to classify. Finally, the qualitative judgment confirmed the choice for 30 as the ideal number of topics.

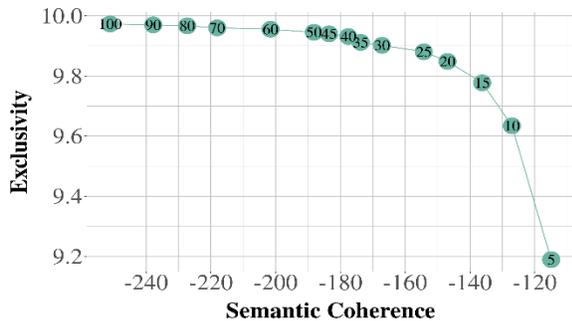


Figure 1: Semantic coherence and exclusivity

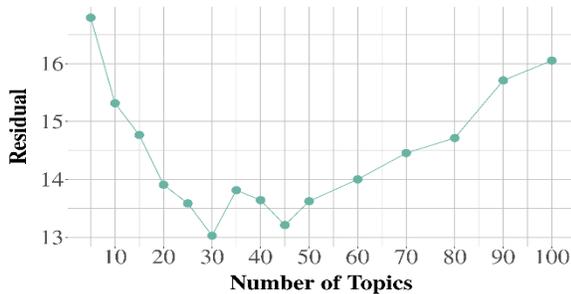


Figure 2: Residuals

Before conducting the content analysis of topics, we assessed their quality by analyzing individual top words, semantic coherence and exclusivity. When inspecting these variables, one result of interest was the low semantic coherence of topic 30, combined with a very high exclusivity. On further inspection using the theta values from the model, which are used to assign every document’s likelihood of a certain topic [33], it became clear that only a single document had topic 30 as most likely topic. Since the top words combined with the highest scoring documents for topic 30 also did not show coherence in our qualitative assessment, we dropped topic 30 from further analysis.

## 4. Results

### 4.1. Topic discovery and visualization

Two of the authors labeled the identified topics independently based on the 10 most frequent words and the most representative reviews for the topic. They compared labels until reaching a consensus on all topics. Then, based on the hierarchical clustering performed with *stmCorrViz* [35], the topic correlation network graph plotted with *stminsights* [36], and a qualitative assessment of the labeled topics, the 29 identified topics were grouped into three themes. The

themes show that reviews express *positive feedback*, *negative feedback*, or *request new features*. Table 2 shows the main themes and corresponding topics.

**Positive reviews.** Most reviews expressed satisfaction with digital wellbeing apps and features, amounting to 43.17% of expected topic proportions (11 topics). In the topics *keeping track* (6.33%), *good for tracking* (3.41%), and *see time spent* (2.99%), users reported how tracking usage time helped them to be more aware of time spent on their smartphones, which in turn motivated them to reduce screen time. *Addiction control* (5.56%) encompassed reviews about how the app effectively helped users to mitigate addiction. In the topic *helpful* (4.81%), users expressed satisfaction about how the app helped them to study, concentrate, and stay focused and productive. The topic *easy to use* (4.45%) included reviews from users who appreciated usability aspects. Users also found the apps to be *good for focusing* (3.76%) on study or work. The topics *study bunny* (3.39%) and *tree* (3.12%) include positive comments about specific apps that use gamification features. In these topics, users expressed their appreciation for the motivation that the rewards gave them to stay focused and be more productive. Finally, in the topics *thanking the developer* (2.89%) and *life changing* (2.46%), users are thankful for being able to change their habits.

**Negative reviews.** The 11 topics from this theme had an expected topic proportion of 35.45%. In *app does not work* (5.51%), users expressed dissatisfaction with app malfunction. *Can’t uninstall* (5.33%) included reviews of those dissatisfied with the fact that they could not uninstall the digital wellbeing app, which they considered bloatware and intrusive. Thus, the decision to offer a digital wellbeing app by default and not allow it to be uninstalled by users might backfire on tech companies such as Google or Apple, which frame these tools as “social goods” to avoid critique and regulation [37]. In *premium version issues* (4.28%), users complained that the premium version did not work after payment, or about the minimal number of features included in the free version. In *problems with daily usage statistics* (4.23%) and *time tracking problems* (3.30%), users reported issues about inaccurate tracking or display of phone usage information. The topics *bad app* (3.16%), *annoying issues* (2.87%), *general problems* (2.52%), and *internet connection requirements* (1.64%) presented a series of general complaints such as *malfunctioning*, *inaccuracies*, *bugs*, and *pro or free version problems*, as well as *compatibility*, *privacy*, and *internet connection issues*. In the topics *block website issues* (2.46%), *time tracking problems* (2.35%), and *bugs in point system* (1.25%), users reported problems with block, tracking, or gamification features, respectively.

Table 2: Topics and main themes

Theme	Topic Label	Highest Probability Words	Example Quote	Proportion
Positive reviews	T11: Keeping track	time, usag, use, limit, wast, dali, spent	<i>I have tested many apps that claim to calculate device usage time. But this is the only app that calculates it most accurately. It's really helping me to realize how much time we waste in smartphones and makes me more productive.</i>	6.33%
	T25: Addiction control	best, addict, mobil, control, applic, social, reduc	<i>Best app I have ever seen to control smartphone addiction.</i>	5.56%
	T18: Helpful	help, lot, product, stay, awesom, student, away	<i>Absolutely helpful for school and to stay productive by far the best productivity app.</i>	4.81%
	T21: Easy to use	great, recommend, look, need, easi, simpl, effect	<i>Pretty satisfied with it! It has a simple design, does what it's expected to do, and for my needs it's the best.</i>	4.45%
	T1: Good for focusing	love, focus, amaz, distract, work, task, get	<i>I love it it helps me to be focused on my work.</i>	3.76%
	T2: Good for tracking	good, keep, track, nice, improv, job, tool	<i>Good Application to keep track of online habits and routines.</i>	3.41%
	T17: Study bunny	studi, motiv, cute, can, fun, bunny, game	<i>I really enjoy this app. I find it motivating for me as a college student and Study Bunny works really for my young nephew too. The graphics are adorable. After you complete a study session, you get coins. With the coins you can buy things for your bunny. You can also buy music with your coins. All the music and sounds are chill and relaxing. I truly think this little app has something for everyone.</i>	3.39%
	T4: Tree	tree, plant, forest, grow, die, can, coin	<i>The best productivity app I've ever used, I paid for premium because of the fact you can plant real trees. Being a lover of the environment, the threat of killing a virtual tree spurs me on to study!</i>	3.12%
	T24: See time spent	much, see, know, timer, spend, long, break	<i>Embarrassed to know my screen on time at first. But it's a good way to let you know how much time you waste on your phone. I would recommend mend this to all that are glued to their phone or get easily distracted.</i>	2.99%
	T9: Thanking the developer	thank, well, develop, perfect, excel, done, wonder	<i>Excellent app and brilliant for restricting usage. It also gives you information on your screen time which is a real eye opener. Overall really pleased with this and I think it will be a big success. Well done to the developers.</i>	2.89%
T8: Life changing	chang, life, hope, made, got, found, guy	<i>Its a life changer for me. I had addictions of ordering food online and watching Netflix because of which i wasn't studying and i was very stressed at the end of the day. I used this app..and i tried different ways to order or to find a loop hole (tried uninstalling the app) whenever my addiction took over me.. but nothing happened..there is no loop hole! its been a week i am eating clean and studying properly..i am very happy with this app..and i am very grateful i found it..thank u!</i>	2.46%	
Negative reviews	T10: App does not work	work, open, still, fix, stop, issu, sometim	<i>Bad experience with the app. sometimes it works and sometimes it doesn't, if it is not running in the background it will not work.</i>	5.51%
	T7: Can't uninstall	updat, cant, uninstal, instal, crash, data, remov	<i>I never installed this app. why is it on my phone? I do not consent to the unauthorized installation to my phone. I do not consent to the app collecting data on me. I do not consent to the app working on my phone. The app won't let me uninstall it! I do not consent to Google deciding things for me.</i>	5.33%
	T5: Premium version issues	featur, version, premium, free, mani, pro, pay	<i>Hello I tried to buy the pro version..I paid but didn't get the version..the money was debited .what to do??? Very bad experience.</i>	4.28%
	T22: Problems with daily usage statistics	use, day, now, start, everi, first, sinc	<i>Still very limited visualizations. I've been using the app for months, but I have no idea how my usage has changed since then. Can only see total usage for every individual day or week by scrolling back day by day. At least give me the option to export my data so I can visualize it myself in a spreadsheet! What's the point of tracking my usage if I can't get an overview of my usage history?</i>	4.23%
	T19: Bad app	tri, say, download, that, wont, review, bad	<i>0/10 do NOT download!!! Everytime I try to use it to block specific apps, I try to use my phone for other things, such as school. Yet this app decides to take it upon itself to keep me from using literally any part of my phone at all. It has been going on for a while and I am officially deleting the app for good because it sucks.</i>	3.16%
	T29: Annoying issues	screen, notif, show, unlock, count, annoy, alarm	<i>The app does not accurately count the number of times I unlock the phone. It says far fewer times than I actually unlocked it.</i>	2.72%
	T3: General problems	problem, back, turn, come, button, home, happen	<i>If I press the home button on my phone the app continues to work but I can still use my phone which defeats the point.</i>	2.52%
	T23: Block website issues	block, site, websit, password, chrome, youtub, browser	<i>The only browser on my phone that it blocks sites on is Chrome. Firefox preview, Firefox focus and Adblock browser all get past this.</i>	2.46%
	T14: Time tracking problems	hour, minut, check, min, challeng, today, sleep	<i>It was very inaccurate. It would tell me I had been on my phone for only five minutes when I knew I had been on it for at least fifteen minutes. Very unhelpful.</i>	2.35%
	T12: Internet connection requirements	without, function, provid, period, requir, internet, rather	<i>This app was offline before the new update and now it says no internet connection and doesn't work if we open the app offline. It was better offline.</i>	1.64%
T16: Bugs in point system	complet, end, session, point, system, watch, wait	<i>I'd assume the preferred behavior is for user to focus for longer periods than shorter periods. But the rewards are exact opposite, I 6 coins for two 10 minute sessions but only 5 for one 20 minute session. Your point system must change.</i>	1.25%	
Feature requests	T6: Whitelist	need, set, abl, allow, access, call, schedul	<i>This is a good app but it might be better to allow us to access some more crucial apps such as whatsapp/ the basic call and messaging systems, so that we can still call some important people while locking our games away.</i>	3.89%
	T26: Customization ideas	like, idea, wish, though, differ, instead, custom	<i>Great idea! I would totally use it if it had some sort of customization to make it unique for each user. i.e. different colors, shapes, floating up instead of falling down, etc.</i>	3.14%
	T28: Star currency	pleas, give, option, add, star, list, suggest	<i>Please add a dark mode and swipe up to go to menu. Make the clock and the menu logo movable to customised locations. If its done I'll give 5 stars.</i>	3.12%
	T13: Locking problems	can, lock, devic, restart, easili, automat, switch	<i>Very useful^^ but it needs more devices to prevent shutting down this app. Especially, after rebooting, it can be easily deleted. Please consider this and make this app not deleted easily.</i>	2.75%
	T20: General requests	mode, android, batteri, digit, googl, widget, launcher	<i>Please pure black background or dark black background.</i>	2.40%
	T27: Finding a way to cheat	way, thing, actual, find, everyth, feel, kind	<i>Exactly the productivity app I've been looking for all these years. Flexible enough to accommodate justifiable "cheating" so that I don't just give up on it, but rigid enough that I won't bother if there isn't a good reason to cheat. But that's also a result of my favorite feature which is the schedule. It reminds me that if I don't absolutely have to check now, I can do it later during a time that's less prone to falling down rabbit holes. I've made so much progress with my social media addiction because of this app, and it's helped me to add hours of free time to my week. Thank you AppBlock for literally changing my life!</i>	2.24%
	T15: Group feature	think, user, peopl, friend, sure, mayb, around	<i>Here's an idea. why not make sharing points between friends more easy and help people compete between them. Would work great for people who want to start competing with their friends and will get more people to use it. Would like to see this option implemented. Other than that, this is an amazing app which can help you get less time on screen. Thanks to all who got to work on it. :)</i>	1.85%

**Feature requests.** The seven topics related to feature requests had a summed expected topic proportion of 19.39%. The most frequent requests were represented by the topic *whitelist* (3.89%), in which users reported that the app was too strict and asked for the option to determine a whitelist of apps and contacts they could access during blocks. In contrast, the topic *locking problems* (2.75%) contained reviews from users who wanted the app to be stricter because they could bypass current locks when restarting their phones. In the topic *finding a way to cheat* (4.24%), many users reported how they could bypass the app's restrictions and asked the developers to solve the problem and make the app stricter. Nevertheless, other reviews from this topic revealed users who liked to have the flexibility of bypassing the restrictions imposed by the app when necessary. *Customization ideas* (3.14%) included suggestions regarding user interface elements. *General requests* (2.40%) covered a series of feature requests concerning UI elements, e.g., dark mode, or for developers to fix a compatibility issue. In *star currency* (3.12%), users reported a certain problem and affirmed they would increase their ratings if the issue were fixed. Finally, the topic *group feature* (1.85%) included requests for a social support feature in the app such as social games or group chats that would enable users to motivate one another.

#### 4.2. Relationship between topics and other variables

Table 3 provides a summary of the estimates on the relation between topics and time, ratings, thumbs up (helpfulness of review), and features.

**Evolution of topics over time.** A comparison of the occurrence of topics over time showed that there were no significant changes in the frequency of most topics. However, some topics presented an upward or downward trend. While the frequency of the topics *easy to use*, *good for focusing*, *good for tracking*, and *study bunny* decreased over time, the frequency of reviews associated with the topics *tree*, *block website issues*, and *general requests* increased over time.

**Ratings and thumbs up.** On a scale from one to five stars, the average rating of the positive reviews was 4.66, followed by feature requests (3.8), and negative reviews (3.05). As expected, almost all topics covering positive reviews presented a positive estimate for stars, which indicates that reviews with high star ratings had a highly significant relation to the positive reviews theme. Topic 4 (*tree*) was the only topic with a negative estimate. After conducting a qualitative assessment of the topic, the authors saw that, while the topic includes both positive and

negative reviews, the most representative documents for the topic cover positive reviews, which justifies its assignment to the positive reviews theme. All negative reviews presented a negative estimate for stars, that is, they had a negative association with high star ratings. Feature requests had mixed results. *Customization ideas*, *finding a way to cheat*, and *group feature* reflected the opinion of users who were satisfied with the app, but wanted to offer additional suggestions. In contrast, *whitelist*, *star currency*, *locking problems*, and *general requests* reflected requests of users who were dissatisfied with the current version of the app and wanted a certain problem fixed. As for review helpfulness, most topics had a positive significant effect on the occurrence of positive reviews, negative reviews, or feature requests. Only four topics among the positive reviews (*addiction control*, *helpful*, *good for focusing*, and *good for tracking*) presented negative estimates.

**Digital wellbeing features.** Each of the apps contained at least one of the following features: self-tracking, block, goal advancement, change UI appearance, gamification, and social comparison. To determine the presence of a certain feature, author 1 went through all the app descriptions in the app store. Table 4 displays the topics that are most or least likely to occur in different digital wellbeing features. As an example, we will describe the findings of the digital wellbeing feature *self-tracking*. Among the selected apps, 63 contained a self-tracking feature. In terms of positive reviews, reviews from apps that had a self-tracking feature were most likely to appear in six of the eleven topics (*keeping track*, *addiction control*, *easy to use*, *good for tracking*, *study bunny*, and *see time spent*). In contrast, four topics were negatively associated with apps that had a self-tracking feature (*good for focusing*, *tree*, *thanking the developer*, and *life changing*). Negative reviews concerning apps with a self-tracking feature were most likely to occur in the topics *can't uninstall*, *problems with daily usage statistics*, *annoying issues*, and *time tracking problems*. Reviews were least likely to occur among the topics *app does not work*, *bad app*, *general problems*, *block website issues*, and *bugs in point system*. Finally, reviews containing feature requests related to apps that have self-tracking features were most likely to appear in the topic *general requests*, and least like to appear in the topics *whitelist*, *customization ideas*, *star currency*, *locking problems*, *finding a way to cheat*, and *group feature*. Please refer to Table 4 for a list of all the topics that were most or least like to occur for the remaining features.

Table 3: Regression estimates for topic prevalence

Theme	Topic Label	Time										Stars	# thumbs up	Feature					
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10			Track	Block	Goal	UI	Game	Social
Positive reviews	T11: Keeping track	-0.109	-0.0298**	-0.178	-0.110	-0.170	-0.186	-0.155	-0.173	-0.195	-0.157	.072	.0000	.0419***	-.0137***	.0286***	-.0003	-.0813***	-.0044***
	T25: Addiction control	-0.0467*	0.008	-0.0099	.0117	-0.081	.0155	.0088	.0059	.0091	-.0022	.0204***	-.0001***	.0181***	-.0118***	.0212***	.0306***	-.0521***	-.0144***
	T18: Helpful	-.0507**	-.0077	-.0171	-.0081	-0.114	-0.075	-0.118	-0.086	-0.136	-0.087	.0160***	-.0001***	-.0009	-.0096***	.0083***	-.0080***	.0055***	-.0089***
	T21: Easy to use	-.0596***	-.0200**	-.0345***	-.0309***	-.0331***	-.0287**	-.0416***	-.0295***	-.0400***	-.0334**	.0120***	.0000***	.0010*	-.0028***	.0001	-.0087***	-.0108***	.0026***
	T1: Good for focusing	-.0576***	-.0160**	-.0244**	-.0235***	-.0206**	-.0176**	-.0200**	-.0202**	-.0173*	-.0205**	.0117***	-.0001***	-.0045***	-.0057***	-.0064***	-.0087***	.0314***	.0091***
	T2: Good for tracking	-.0650***	-.0308***	-.0396***	-.0332***	-.0400***	-.0355***	-.0364***	-.0361***	-.0399***	-.0354**	.0059***	-.0001***	.0054***	-.0049***	.0097***	-.0017**	-.0134***	-.0019***
	T17: Study bunny	-.1253***	-.0613***	-.0791***	-.0730***	-.0647***	-.0695***	-.0795***	-.0662***	-.0673***	-.0741***	.0092***	.0000*	.0072***	.0405***	.0098***	.0172**	.1292***	-.0520***
	T4: Tree	.1672***	.0778***	.0865***	.0833***	.0728***	.0763***	.0711***	.0894***	.0674***	.0731***	.0013***	.0001***	-.0091***	-.0429***	.0027***	-.0329***	.0332***	.0271***
	T24: See time spent	.0089	-.0102	-.0054	-.0057	-.0039	-.0071	-.0075	-.0045	-.0061	-.0020	.0040***	.0000***	.0106***	.0013**	.0077***	.0032**	-.0103	-.0017**
	T9: Thanking the developer	.0042	.0010	-.0026	.0038	-.0027	.0025	.0018	.0002	.0016	-.0013	.0080***	.0000	-.0038***	.0012**	-.0017***	-.0016*	-.0036***	-.0008*
T8: Life changing	.0091	-.0040	.0075	-.0009	.0035	.0005	.0032	.0080	.0024	.0066	.0041***	.0000	-.0027***	.0024**	.0010*	.0034**	-.0009	.0000	
T10: App does not work	-.0169	.0220*	-.0010	.0000	-.0066	-.0072	-.0068	-.0240*	-.0064	-.0111	-.0144***	.0000**	-.0065***	.0022**	-.0010	-.0091***	-.0028**	-.0008	
T7: Can't uninstall	-.0068	-.0139	-.0023	-.0104	.0102	.0051	.0186	-.0020	.0172	.0027	-.0315***	.0000*	.0253***	.0085***	-.0089***	-.0131***	-.0013	-.0020*	
T5: Premium version issues	-.0583**	-.0119	-.0214	-.0040	-.0193	-.0107	-.0031	.0103	-.0153	-.0024	-.0100***	.0001***	.0001	-.0087**	.0066***	-.0174**	-.0170***	.0201***	
T22: Problems with daily usage statistics	.0014	-.0103	-.0149	-.0108	-.0143	-.0137	-.0081	-.0143	-.0138	-.0104	-.0053***	.0000**	.0097***	-.0007	.0076***	-.0013	-.0102***	.0034***	
T19: Bad app	.0118	-.0037	.0026	-.0014	.0003	.0007	.0040	.0001	.0076	.0039	-.0060***	.0000*	-.0022***	.0026***	.0028***	-.0057***	.0004	-.0019***	
T29: Annoying issues	-.0064	-.0154	-.0103	-.0199*	-.0114	-.0182	-.0174	-.0175	-.0144	-.0196*	-.0055***	.0000**	.0059***	-.0043***	-.0029***	.0167***	-.0175***	.0014*	
T3: General problems	.0052	.0085	.0014	-.0002	-.0008	-.0012	-.0014	-.0065	-.0026	-.0022	-.0062***	.0000***	-.0079***	.0027***	-.0021***	-.0002	.0084***	-.0001	
T23: Block website issues	.0908***	.0573***	.0797***	.0842***	.0600***	.0742***	.0713***	.0677***	.0732***	.0706***	-.0036***	.0000*	-.0486***	.0111***	-.0062***	-.0206***	-.0127***	-.0046***	
T14: Time tracking	.0107	-.0020	-.0032	-.0071	-.0070	-.0115	-.0031	-.0145*	-.0036	-.0088	-.0016***	.0001***	.0079***	-.0009*	.0082***	.0031***	-.0141***	-.0029***	
T12: Internet connection requirements																			
T16: Bugs in point system	.0069	-.0049	.0003	-.0019	-.0024	-.0015	-.0038	.0006	-.0073	.0139**	-.0005***	.0000***	-.0002	.0026***	-.0025***	.0020***	.0008*	-.0001	
T6: Whitelist	.0027	.0022	.0026	.0013	.0004	.0018	-.0001	.0013	.0050	-.0020	-.0012***	.0000***	-.0005*	.0026***	-.0003	.0000	.0113***	-.0026***	
T26: Customization	.0226	.0316***	.0182*	.0106	.0226*	.0071	.0127	.0050	.0128	.0083	-.0066***	.0000**	-.0139***	.0155***	-.0276***	.0207***	.0131***	.0021***	
T28: Star currency	.0449***	-.0055	.0119	-.0031	.0123*	.0053	-.0005	.0052	.0046	.0026	.0013***	.0001***	-.0091***	-.0001	-.0118***	.0162***	.0123***	.0040***	
T13: Locking problems	.0142	-.0003	.0015	-.0009	.0042	.0013	.0075	.0011	.0064	.0045	-.0019***	.0000	-.0069***	.0042***	-.0063***	.0063***	.0111***	-.0060***	
T20: General requests	-.0206*	.0193**	-.0015	-.0002	-.0040	-.0022	.0000	-.0031	.0006	-.0017	-.0022***	.0000***	-.0165***	.0050***	.0071***	-.0136***	-.0198***	.0016***	
T27: Finding a way to cheat	.1071***	.0222**	.0656***	.0552***	.0747***	.0597***	.0610***	.0599***	.0606***	.0602***	-.0040**	.0000**	.0025**	-.0003	-.0392**	.0188**	.0029*	.0134**	
T15: Group feature	.0019	.0024	.0015	-.0007	.0033	-.0014	-.0004	.0010	.0009	.0014	.0008***	.0000**	-.0005*	.0022***	-.0011***	-.0003	.0029***	-.0003	
	.0126*	-.0056	.0051	-.0025	.0013	.0009	-.0038	.0071	-.0034	.0030	.0007***	.0000***	-.0017***	.0001	-.0013***	.0028***	.0018***	.0027***	

\*p < .10. \*\*p < .05. \*\*\*p = .001.

Table 4: Most and least likely topics for all features

Digital wellbeing feature	Number of apps	Theme		
		Positive reviews	Negative reviews	Feature Requests
Self-tracking	63	<b>most likely:</b> 11, 25, 21, 2, 17, 24 <b>least likely:</b> 1, 4, 9, 8	<b>most likely:</b> 7, 22, 29, 14 <b>least likely:</b> 10, 19, 3, 23, 16	<b>most likely:</b> 20 <b>least likely:</b> 6, 26, 28, 13, 27, 15
Block	55	<b>most likely:</b> 17, 24, 9, 8 <b>least likely:</b> 11, 25, 18, 21, 1, 2, 4	<b>most likely:</b> 10, 7, 19, 3, 23, 12, 16 <b>least likely:</b> 5, 29, 14	<b>most likely:</b> 6, 28, 13, 27 <b>least likely:</b> none
Goal advancement	17	<b>most likely:</b> 11, 25, 18, 2, 17, 4, 24,8 <b>least likely:</b> 1, 9	<b>most likely:</b> 5, 22, 19, 14 <b>least likely:</b> 7, 29, 3, 23, 12	<b>most likely:</b> 13 <b>least likely:</b> 6, 26, 28, 20, 27, 15
change UI appearance	9	<b>most likely:</b> 25, 17, 24, 8 <b>least likely:</b> 18, 21, 1, 2, 4, 9	<b>most likely:</b> 29, 14, 12 <b>least likely:</b> 10, 7, 5, 19, 23	<b>most likely:</b> 6, 26, 28, 20, 15 <b>least likely:</b> 13
Gamification	17	<b>most likely:</b> 18, 1, 17, 4 <b>least likely:</b> 11, 25, 21, 2, 24, 9	<b>most likely:</b> 3, 12, 16 <b>least likely:</b> 10, 5, 22, 29, 23, 14	<b>most likely:</b> 6, 26, 28, 20, 27, 15 <b>least likely:</b> 13
Social support	11	<b>most likely:</b> 18, 21, 1, 4 <b>least likely:</b> 11, 25, 2, 17, 24, 9	<b>most likely:</b> 5, 22, 19, 29 <b>least likely:</b> 7, 23, 14, 16	<b>most likely:</b> 6, 26, 13, 20, 15 <b>least likely:</b> 28

## 5. Discussion

This study analyzed user perceptions of digital wellbeing features to suggest future research areas to extend existing knowledge on IT addiction mitigation. Overall, the identified drivers of satisfaction and dissatisfaction corroborate with those of previous research [7]. In addition, the STM analysis of reviews allowed us to uncover novel insights to guide future research on the development of digital wellbeing tools, namely the potential of self-monitoring, goal advancement and change UI features, the mixed demands from users in terms of block features, and the questionable benefits of gamification features.

### 5.1. Controlling addiction: features that can bring users from life online to the real world

After analyzing the effect of specific digital wellbeing features on the nature of reviews, we found self-monitoring, goal advancement, and changing UI appearance to be the most associated with addiction control. Self-monitoring features were the most mentioned among satisfied users. In their reviews, users expressed how tracking and visualizing their usage data increased awareness and allowed them to regain control. Although previous research has considered self-monitoring features to be insufficient promoters of new habits [7], our findings reinforces the importance of awareness to mitigate smartphone addiction [20]. Despite their potential, research that focuses on which information to track or how self-monitoring information should be presented to users is still scarce [38, 39]. In this context, future research could use Social Cognitive Theory to investigate how the design of self-monitoring features affects users' self-regulation, self-control and self-efficacy [40] toward mitigation of IT addiction. As for goal

advancement and change UI appearance, such features might effectively help users to control addiction by keeping them intrinsically motivated or decreasing the appeal of the device, respectively. However, further research into how these features affect users is necessary. Thus, investigating self-monitoring, goal advancement, and change UI appearance features are promising paths into digital wellbeing research.

### 5.2. Finding a way to cheat: are block features too strict or not strict enough?

Users present mixed demands in terms of block feature restrictiveness. Block features were associated with topics in which users thank the developing team and consider the app to be life changing, which might reflect the opinion of those with higher levels of smartphone addiction, who have no problems in relinquishing control to ensure that they can reduce unwanted behavior. However, block features were also the most associated with negative reviews, oftentimes because users considered them too strict or not strict enough. Feature requests also revealed contrasting user opinions in terms of restrictiveness. While some users do want more restrictive options as suggested by [7], our analysis demonstrates that there is a substantial number of users who are concerned about their autonomy and want more flexible features such as whitelists. Thus, we confirm that many users share the ethical concerns discussed by previous research on block features and their potential adverse effects. It is also important for researchers to consider other variables besides effectiveness, e.g., satisfaction, perceived autonomy, FOMO. Although block features have been found to promote wellbeing [41, 42], our findings show that there is no "one size fits all" solution. Thus, future research could investigate what personal characteristics affect users' interaction with block features, or how different profiles of users [1] react to different levels of restrictiveness.

### 5.3. Are gamification features really game changers?

Our findings also show users' preferences toward gamification features, which were the least related to negative reviews. However, while users appreciate gamification features, they do not report them as being particularly helpful to control addiction. This finding supports the claim that purely hedonic features should be avoided to prevent addictive behavior [10], as they can keep the user focused on the reward, reducing intrinsic motivation and impeding the development of automaticity [24]. As one user wrote in a review about Forest, an app in which users can grow virtual trees through non-use: “*One gets bored when all the trees are unlocked*”. Nevertheless, the reviews showed that users found gamification helpful to keep them focused during certain tasks. Therefore, future research could explore the design of features that promote the bright side of gamification while avoiding its dark side. That is, research on gamification could explore how the association of such features with others that promote intrinsic motivation, e.g., self-monitoring, might be more effective in promoting self-determination and long-term behavior change. To the best of our knowledge, digital wellbeing researchers have not yet explored gamification features.

### 6. Conclusion

As smartphone addiction can cause a series of negative effects, there is a need to investigate mitigation mechanisms against IT addiction. As digital wellbeing features have surged with the purpose of helping users control their smartphone use, it is key to understand how users perceive these features to design features that can effectively assist users without promoting unintended consequences. We applied structural topic modeling to uncover emerging themes concerning digital wellbeing apps and investigated how the topics relate to different digital wellbeing features. With our insights into users' perceptions of digital wellbeing features, we highlight promising research areas, that, once explored, could bring researchers closer to reach a consensus regarding the proper design of digital wellbeing features and tools.

In addition, our topic modeling analysis was able to uncover similar concepts to the content analysis of user reviews performed by [7], while also associating latent topics and themes with digital wellbeing features, as well as identifying feature requests. This makes topic modeling a less effortful technique to discover broad topics from a large set of reviews that yielded comparable results to human coders.

We also provide practical contributions in the form of drivers of satisfaction and dissatisfaction among users, as well as feature requests (e.g., whitelists, social support features), which can guide developers with information about potential features to be implemented or how to improve current apps.

Our study also has limitations. First, as mentioned by [28], the process of identifying topics might be prone to biases. To mitigate this limitation, we followed their recommendations and had two of the authors engaged in the topic identification and labeling process. Second, while we considered the relation of features to the topic, it might be that the combination of certain features also influenced users' perceptions regarding such apps. Thus, future research should also consider specific combinations of features when analyzing their effects on users' perceptions. Finally, our findings' generalizability is limited to our dataset, which encompassed play store reviews of digital wellbeing apps in the US region. By using additional data, e.g., reviews from iOS apps or social media posts, future research could overcome this limitation.

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