Why do people take Screenshots on their Smartphones?

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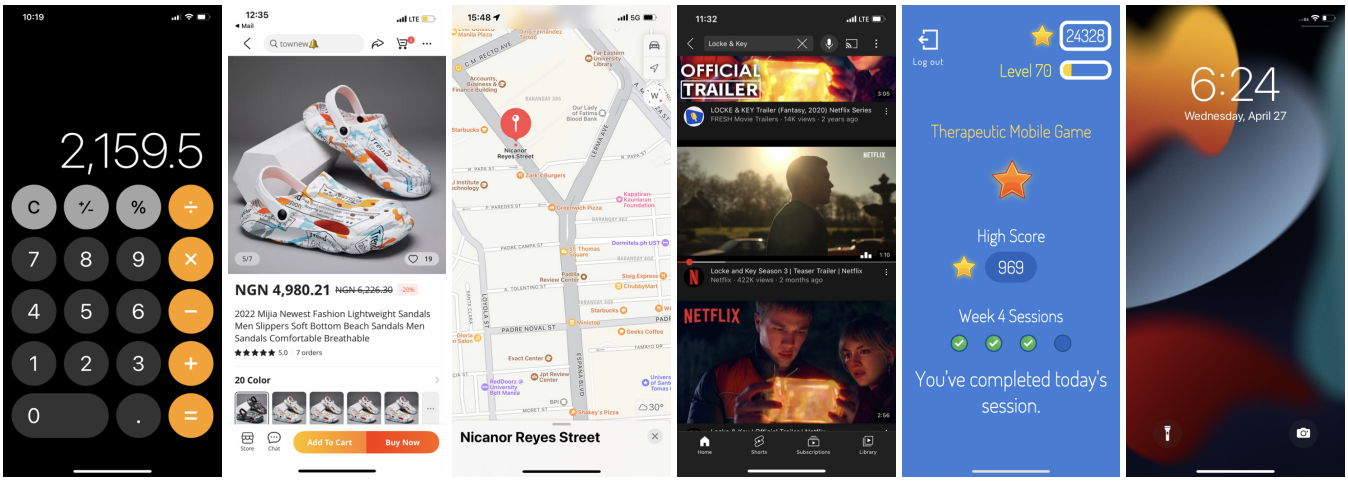


Figure 1: Six sample screenshots collected in this study show the breadth of reasons why people take and store screenshots. Our study revealed common and uncommon screenshot practices, that we argue are mostly unsupported by current mobile applications and operating systems. From left-to-right: (1) a screenshot of the calculator app to remember an intermediate calculation; (2) a screenshot of a shopping application for future purchase consideration; (3) a screenshot of a map application intended for offline route planning; (4) a screenshot of movie trailers for inspiration; (5) a screenshot of a mental health game for storing a trophy; and (6) a screenshot of the clock on the lock screen to store the time of a personally significant event.

ABSTRACT

Screenshots are ubiquitous in mobile computing, yet poorly understood. This paper advances our understanding of reasons for capturing, storing, and sharing screenshots. A crowdsourced user study was conducted where 52 participants shared personal screenshots from their phones, alongside textual reasons for why they were captured. Using mixed methods analyses we uncover common and uncommon screenshot practices that have not previously been documented. By analyzing the language used to describe reasons for taking screenshots, we document a variety of motivations for screenshot captures that provide opportunities for design. We furthermore report nine overarching themes in contemporary mobile screenshot use, considerably extending the currently held view of screenshots as a type of social computing. To inform design, we propose novel screenshot-centered interaction concepts that bridge the empirical findings. Last, we position screenshotting as a style of mobile interaction, which we argue is an undeveloped opportunity for advancing interactivity for mobile computing.

CCS CONCEPTS

• **Human-centered computing** → **User studies**; *Mobile phones*; Empirical studies in HCI.

KEYWORDS

screenshots, crowdsourcing, mobile interaction, data set, empirical study, user behavior

ACM Reference Format:
Aske Mottelson. 2023. Why do people take Screenshots on their Smartphones?. In *Designing Interactive Systems Conference (DIS '23), July 10–14, 2023, Pittsburgh, PA, USA.* ACM, New York, NY, USA, 13 pages. https://doi.org/10.1145/3563657.3596067

DIS '23, July 10–14, 2023, Pittsburgh, PA, USA

ACM ISBN 978-1-4503-9893-0/23/07…$15.00
https://doi.org/10.1145/3563657.3596067

1 INTRODUCTION

Screenshots represent the content of a screen in pixels from a brief moment in time. Although the word *screenshot* came considerably later, screenshots were conceptualized in the 1960's [1]. The emergence of screenshots during this period has been argued to be a cornerstone in computing history, specifically in the realization and dissemination of the interactive computing paradigm, by providing

a *second-hand impression of the experience of using an interactive computer* [1] when computers were still mostly inaccessible. Today, screenshots continue to play an important role in computing. With the increased adoption of smartphones, screenshots have become ubiquitous means for a variety of computational and social interactions, such as for sharing knowledge, news, for entertainment, for habitual reasons, and to store memories [7].

Screenshots are technically bitmap representations of screen contents with little to no contextual information, although their use go far beyond their value in pixels. Thought provokingly, earlier implementations of screenshots, such as through the BASIC command `BSAVE`, stored raw contents of the memory to a file, that allowed recreation of computational state for later execution; a practice that has later been discontinued.

Screenshots were initially literal photographs of screens that required somewhat elaborate technical arrangements to be taken [1]. Today, the technical barrier for capturing screenshots is almost non-existing, as they are commonly taken by just combining two button presses. A recent survey study [7] found that 97% of respondents had previously captured and shared a screenshot, hence documenting the ubiquity of screenshot use in the context of mobile and social computing.

As screenshot use has become commonplace, the purpose of capturing screenshots may appear self-evident. The empirical investigations on screenshot use (e.g., [7, 14]) are primarily motivated by their social function; either for communication of information or for documentation of communication. Consequently, the extent and varieties of mobile interactions people engage in using screenshots, surpassing their social function, are poorly understood. The overarching goal of this paper is to understand such use; we believe that understanding contemporary screenshots and screenshot use, can reveal important opportunities for interaction design in the context of mobile computing.

In this paper we therefore investigate what people use screenshots for, and based on empirical findings, identify design opportunities for screenshot use. To explore current use of screenshots we devised a crowdsourced mobile study, where participants shared actual screenshots from their smartphones together with motivations for taking them. We use a mix of quantitative and qualitative analysis methods to uncover practices that can motivate the design and development of novel mobile computing concepts. We document nine overarching reasons for why people take mobile screenshots which decisively extends current known motivations behind screenshot use. We show that screenshots have diverse, creative, and oftentimes idiosyncratic functions that have not previously been explored. We find that screenshots are both artifacts that are stored for utilitarian reasons (e.g., for bookmarking or for enabling offline use); but also that the action of capturing a screenshot is a rich interaction style that affords meaningful experiences (e.g., for capturing moments of joy or as sentimental diary entries). We argue that most of current screenshot practices are poorly understood, unsupported by present mobile computing, and are mostly ignored in design.

Fifty-two participants shared 1679 screenshots and their motivations for taking them. We employed both quantitative and qualitative analysis techniques to understand the collected data. From these analyses we aim to answer the question posed in the title: *Why do people take screenshots?* The answers to this non-trivial question are followed-up with a review of selected screenshot practices; we present and discuss these as opportunities for mobile computing to more deeply engage in screenshots as a rich interaction style. The paper ultimately presents the following contributions:

(1) Summary statistics of a heterogeneous data set of participant provided mobile screenshots and associated descriptions
(2) Computational analyses of sourced data
(3) An affinity diagram of sourced data
(4) Descriptions of contemporary screenshot practices
(5) Design opportunities for screenshots derived from quantitative and qualitative analyses

2 RELATED WORK

Research about why people take, store, and use screenshots is limited. Most scholarly work about screenshots, in particular on mobile devices, relate to specific applications, such as generating user interface (UI) code, extracting meta data, or studying user behavior through automatic screenshot capture [2, 4, 5, 8, 9, 13, 15, 18, 22, 28–33]. Because of the limited empirical research on screenshot practices, we here review academic work that relates to screenshots, without they necessarily document reasons why people take them in the first place. Finally, we review public screenshot collections, their potential to inform us about screenshot use, and the type of research they have facilitated.

2.1 Empirical research about screenshot use

Despite the extent of screenshot use in everyday (mobile) computing, there are remarkably few empirical investigations of why people take and store screenshots. Some noteworthy exceptions [7, 14] studied screenshot use among teenagers and college students, and document screenshot activity as a complex social phenomenon that can enforce hierarchical structures. Furthermore, a few studies about applications of screenshots include empirical observations about niche uses of screenshots, such as in academic publishing [22] and in software testing [31].

An exploratory survey study by Cramer et al. [7] inquired participants about their screenshot use and motivations thereof. The authors report the most commonly answered motivations behind screenshot captures, which related to, among other things, sharing information, entertainment, and capturing social media. The study furthermore reported age differences in prevalence and motivations for taking screenshots. The authors report a wealth of descriptive statistics on general screenshot use, such that 97% of their sample had sent a screenshot to someone else.

A comprehensive investigation about the 'social life' of screenshots beyond their technical function was published by Jaynes [14]. An ethnographic study with 27 teenage participants was conducted to uncover how screenshots are used in digital communication, and what makes them significant to their peers. Jaynes argue that screenshots, specifically among teenagers, are integral in negotiating hierarchies of friendship and power. Jaynes's noteworthy and concerning findings show how screenshot practices among teenagers have strong social implications. The author posits that screenshots can function as a type of *peer surveillance* used to underpin power structures.

2.2 Screenshots in computational use

Screenshots have computational use in a variety of contexts, such as in information retrieval [5, 15], analysis of software test reports [31, 32], for UI code generation [2, 18], and for analyzing mobile user behavior [9, 29]; we review such applications here.

Extracting information from screenshots. Kumar et al. [15] presented a privacy-preserving pipeline to make screenshots searchable. They performed on-device text extraction and subsequent keyword matching, enabling users to retrieve screenshots from text queries.

Embedding information in screenshots. In studying screenshot use in academic literature, Pareddy et al. [22] found that screenshots are often used to represent information that is not structurally preserved in image formats. Specifically, screenshots in academic use often depict structural content (e.g., tables), that is not readily available through rasterized image formats. The authors propose a solution by embedding semantic information in image files, thereby preserving information lost by rasterization.

Screenshot relations. A large body of research deals with automatically inferring relations among screenshots, such as similarity [9] and clustering [4]. Feiz and authors [9] presented two such algorithms for detecting screen similarity and screen transition from screenshots, respectively. Their work shows utilization of screenshots as training data for technology that can advance our understanding of design. Chiatti and colleagues [4] also proposed a machine learning model trained on screenshots. The authors note the degree of sensitivity of screenshot data that makes them unfit for crowd-based annotation. The authors instead experiment with unsupervised approaches to clustering to discover latent classes in systematically created screenshots.

Software testing. Considering crowdsourced software testing, Yu et al. [31] noted how screenshots often accompany test reports, even if they are commonly disregarded in favor of textual descriptions. The authors conceptualized, prototyped, and evaluated a system that utilized the information embedded in crowd provided screenshots of software errors to easen the burden for developers in accessing software reports. They furthermore devised an algorithm that based on screenshots and textual descriptions estimated the quality of such software error reports [32].

UI parsing and generation. Generating appropriate code for graphical user interfaces (GUIs) from visual or textual prompts is a standing challenge in machine learning and HCI. Several works use screenshot data sets with labelled UI elements to foster automatic interface generation such as *pix2code* [2] and ReDraw [18]. Wu et al. [28] furthermore described a system for inferring UI elements and their underlying structures from screenshots. Motivating their work by the term *screen parsing* they furthermore explain use cases from such modeling apart from UI generation, including improved UI search and accessibility. Zang et al. [33] also performed classification of UI elements from screenshots. By combining view hierarchies and pixel input, they achieve high accuracies for automatic classification of UI elements. Last, Todi et al. [27] studied users querying a database of UIs to reveal design implications of systems dealing with screenshots of applications.

Other screenshot applications. Other applications of screenshots include *Scrapbook* [13], that enables knowledge workers to curate digital resources with screenshots for later retrieval, and *Sikuli* [30], an application that allows users to input screenshots for querying a database of UI designs.

2.3 Data sets

We inspected public screenshot data sets to identify if they could aid our research goals, or if studies of screenshot behavior had been carried out using such data sets. Several open source data sets with associated publications relating to screenshots exist (e.g., [5, 8, 9, 18]). Feiz et al. [9], for instance, had human crowd workers traverse selected popular iOS apps, and collected 77,000 screenshots with the purpose of automatically inferring relations of visual app content. Similarly, Deka et al. [8] released *Rico*, a data set intended for data-driven mobile design. It features 66,000 Android screenshots with accompanying screen page labels (e.g., 'login page'). Also, Moran et al. [18] released a data set collected for their system ReDraw. It features almost 200,000 screenshots of UI elements (e.g., `Button` and `ImageView`). Chiatti et al. [5] released a data set of more than 900,000 screenshots, taken automatically every 5 seconds, from 52 participants. The data set therefore affords analyses of mobile use, rather than practices related to screenshots captured by users themselves. Other noteworthy (non-academic) data sets of screenshots are `prnt.sc`[1], an enormous collection of real-time automatically sourced screenshots from tweets, and the `Website Screenshots data set`[2], a large collection of web-scraped screenshots with annotated UI elements.

In summary, available data sets of screenshots are relatively common, but relate to user interfaces or user behavior. They are either synthetically generated or are systematically created based on experimental protocols. Therefore, studies employing these data sets can inform data-driven design, automatic UI generation, user modeling, or computational interaction. To our knowledge there are no public data sets with ecological (mobile) screenshots, that contain screenshots and/or motivations for capturing these, provided by users themselves. Consequently, there has not yet been conducted studies that investigate everyday screenshot activity with the goal of uncovering mobile interaction practices and opportunities.

2.4 Open Questions

Screenshots have a variety of computational and social uses. They have been suggested, among many other uses, for modeling user behavior [29], for automatic user interface parsing and generation [28], for information retrieval [5], and for software testing [31]. Many systems have been envisioned where screenshots play an integral part of functionality or as training data for machine learning-led classification purposes. Despite the massive utilization of screenshots and the evident ubiquity in personal screenshot use, little is known about the actual practices of screenshots in everyday mobile computing, especially from a human-computer interaction perspective. Only few empirical studies have shed light on contemporary screenshot practices [7, 14]. These studies concern screenshot use

[1] https://prnt.sc
[2] https://public.roboflow.com/object-detection/website-screenshots

with regards to social media, and their social implications for selected age groups. The empirical data explains the prevalence of screenshot use, and the most common self-reported motivations; yet, little is known about the actual screenshots residing on peoples smartphones, and their implications for interaction, design, and mobile computing in general.

We therefore lack systematic empirical HCI research addressing screenshot practices that informs us about mobile computing practices. The lack of knowledge of positive, personal, utilitarian, affective, or otherwise benign screenshot activities, continue to obstruct development of meaningful design explorations and novel interaction styles for screenshot use on mobile devices. Uncovering such practices can not only bring knowledge about a commonplace, yet poorly understood computing phenomenon, but can also reveal design opportunities for mobile applications and operating systems alike.

3 CROWDSOURCING DATA

To understand why screenshots are taken and stored, what meaning they represent, and ultimately to identify opportunities for interaction design, we carried out a user study where we collected ecological data on participants' actual screenshot practices. We were interested in collecting actual screenshot imagery alongside subjective reasoning to allow for computational and manual analyses of contemporary screenshot use. With inspiration from the mobile computing literature that sourced user stories through mobile apps (e.g., [10, 19, 20, 23, 24]) we devised a mobile application for collecting ecological screenshot data and associated descriptions. Distributing our study through the app store enabled us to locate and filter relevant screenshots automatically (based on date and image resolution), and it provided a seamless interface for participants to annotate their screenshots. Deploying the study as a web application would have required participants to manually identify individual screenshots, and could have tainted the sample as it would be harder to qualify the validity of individual screenshot uploads.

3.1 Participants

Fifty-two participants, who all used an iPhone as their primary smartphone participated in the study. We advertised the study through social media. The participants were aged between 20–48 years (M = 27.9, SD = 6.2). A free-text input field revealed that 26 participants identified as male, nine as female, and one as non-binary. Participants' nationalities were distributed across seven countries: most participants were from the US (68%), with the remaining participants from Chile, India, Philippines, Canada, Egypt, Nigeria, and England. Fifteen participants opted out of sharing information about gender or country of origin. Twenty-six individuals installed our experimental application, but did not provide the application with permission to access the photo library, and could therefore not share any screenshots; these individuals were omitted from analyses. Participants were reimbursed relative to the number of screenshots shared; when sharing one hundred screenshots (the maximum allowed) they were given a gift card worth $10 USD.

3.2 Apparatus

We developed the app for iOS 15.0 or newer (targeting iPhone 6s or newer). The app acquired informed consent, demographic data, and permissions for photo library access. The app was written in Swift 5 using the SwiftUI library. User provided data were encrypted and stored using AWS S3. The app was distributed on Apple's App Store.

3.3 Study Design

Once a participant completed the initial screens (informed consent, permissions, demographics) the app proceeded to show the hundred most recent screenshots from the participant's photo library, one at a time. A screenshot of the research study app is shown in Figure 2.

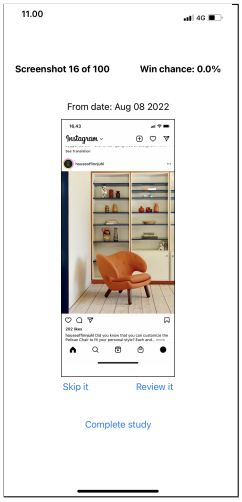


Figure 2: A screenshot from the study app used to source screenshot data. This screen asks participants to either share a particular screenshot (by tapping *Review it*), skip it, or complete the study altogether.

The number of maximum 100 screenshots per participant was chosen as a trade-off between collecting a robust data set, without having few participants contributing the majority of screenshots. We furthermore restricted the eligible screenshots to be at most one year old as to not ask participants to recall a potentially lost memory of why a particular screenshot was taken. Participants could choose to review any given screenshot or skip it. Reviewing the screenshot entailed explaining which app the screenshot was taken of, why it was taken, and to whom it was intended. Responses were collected from free-text fields. The free-form response was deliberately chosen, despite the overhead in analysis, to not prematurely limit the breadth of responses. The study followed the institution's and Apple's ethical review process. Table 1 specifies the collected variables.

3.4 Summary Statistics

From fifty-two participants we sourced 1679 screenshots with accompanying responses (refer to Table 1 for an overview of collected variables). Participants each submitted between 1-100 screenshots

Per participant	Per reviewed screenshot
Age	Screenshot in PNG
Gender	Name of app in screenshot
Nationality	Personal/for sharing
iPhone model	Reason it was taken
iOS version	Timestamp
Screen size	
Number of screenshots in photo library	
Timestamps of screenshots	

Table 1: The collected variables of the study.

($M = 32.3,\ SD = 34.7$). We furthermore collected meta data about all screenshots on participants' devices.

Our records show that taking and storing screenshots is indeed very common: the mean number of screenshots stored in the photo library across participants was 498.8 ($SD = 705.3$, median = 195). Meta data show that screenshot activity occurs throughout the day with a peak at 8pm; the lowest frequency of screenshot activity is observed at midnight; furthermore with noticeable local minima at approximately 5am and noon; see Figure 3a.

We furthermore find that approximately 24% of screenshots were taken with the intention to share with others (hence, 76% of screenshots were unintended or intended for personal use).

We collected screenshots from 140 apps at minimum represented by two participants; Figure 3b shows the most common apps that participants from present study capture screenshots of: Instagram, Safari, and Facebook are the top three most present in our sample. These three apps together account for more than 30% of all screenshots in our sample. Organizing the screenshot distribution by app category reveals social media, browsing, and messaging apps as the dominating; see Figure 3c.

4 ANALYSES

We analyzed the collected data in two ways: (i) a quantitative analysis using natural language processing techniques intended to uncover trends and commonalities, and (ii) a qualitative analysis based on affinity diagramming intended to uncover themes across practices and specific screenshot related behaviors of interest.

4.1 Quantitative Analysis

We first analyzed the collected data computationally, specifically using Python and the packages `pandas`, `numpy`, and `nltk`. For each screenshot we considered the following information:

Label	Description	How	Data type
reason	The reason for taking the screenshot	participant	String
app_name	Name of app	participant	String
category	App category	computed	String

Table 2: The variables used for computational analyses of the sourced data.

4.1.1 Data cleaning and normalization. We identified and matched misspellings in app names manually (e.g., 'homescreen' and 'home screen'), and grouped applications with common name variants (e.g., 'google chrome' and 'chrome'). We continued this practice until all names were resolved.

We cleaned and normalized the textual descriptions of screenshots by lower casing, by removing stop words, by correcting misspelled words (using GNU Aspell[3]), by replacing words with the US spelling variant, and finally by lemmmatization.

4.1.2 Corpus.

Description. Participants provided short textual reasons for taking each screenshot. These descriptions ranged from 5 to 363 characters ($M = 37.8,\ SD = 33.1$). We removed identical reasons given by the same participant (there were 459) to not inflate subsequent natural language processing (note that these might be valid reasons, for instance because of series of similar screenshots). We concatenated all 1164 descriptions into one string of 43,057 characters, and split it by white space into a list of 7279 words (2342 distinct).

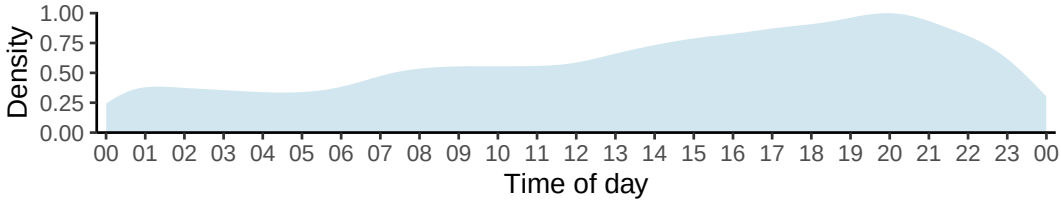
Common words. The most common words in the corpus (stop words excluded), and as such the most frequent words to describe the purpose of taking a screenshot, were *funny*, *friend*, *remember*, *share*, *reference*, *picture*, *boyfriend*, and *love*. These words together show that sharing entertaining content with a significant other is a common reason for taking a screenshot, as previously documented [7].

Four-grams. To inspect common word patterns we computed four-grams. The most common four-grams reveal that reasons for taking screenshots are mostly social; often for sharing or showing information and content with a friend or a spouse. The most common four-grams were: (1) *to send to my*, (2) *to show my friends*, (3) *to show my husband*, and (4) *to make fun of*.

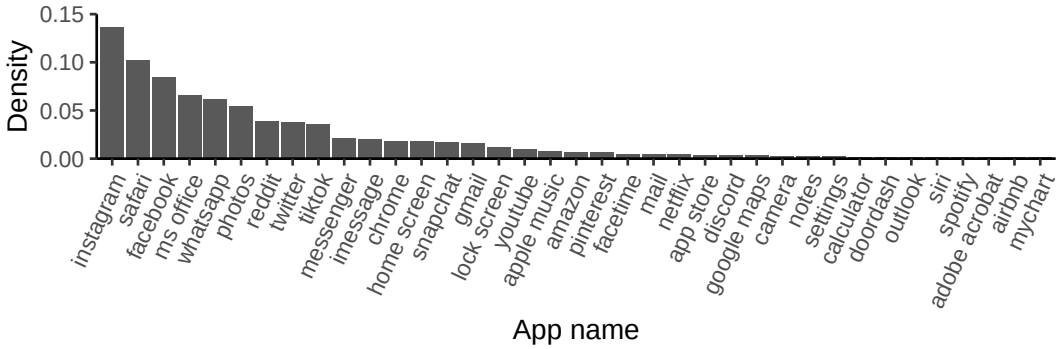
Part-of-speech. After performing part-of-speech (POS) tagging and subsequent lemmatization[4], we identified the most frequent words by grammatical function (see Figure 4). Figure 4 shows that the adjectives used to describe screenshots are foremost of positive sentiment (i.e., *funny*, *cool*, *cute*, *good*); the nouns relate to relationships (i.e., *friend*, *boyfriend*) or social content (i.e., *picture*, *post*, *meme*, and *message*); finally the verbs tend to refer to affective actions (i.e., *remember*, *share*, *love*, *keep*, *save*). The POS tag analysis reveals that mobile screenshot activity functions as an important social interaction that engages affectionate relationships; unlike the original purpose of the screenshot for documenting interactivity [1].

4.1.3 Distinct screenshot practices. A per category investigation of common language use can expose screenshot practices related to app type, that would otherwise be concealed by the most common practices in analysis of the general corpus. For each app category we therefore computed the most commonly used words based on the reasons provided for taking a screenshot. The frequencies of words within each category were then normalized by the frequency across categories, such that we could derive words distinctly associated to specific categories, that may reveal certain screenshot behaviors that were not captured by previous omnibus analyses. Normalization was furthermore conducted to avoid repetitious patterns across categories (e.g., *fun*, *share*, *remember*). The type of output by this analysis (i.e., distribution of words across topics) is

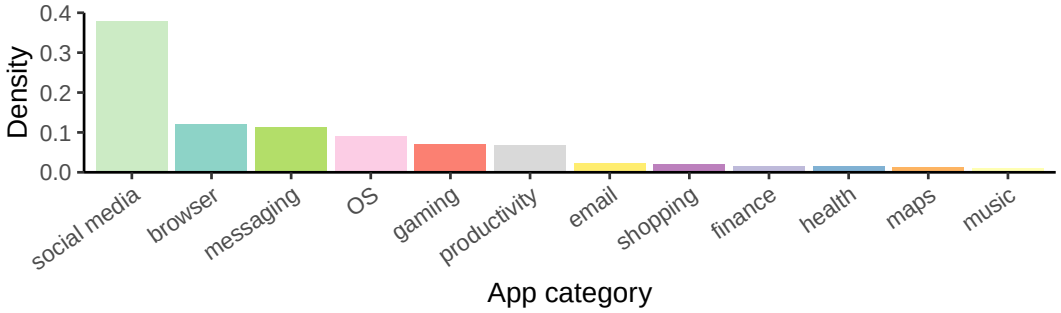
[3] http://aspell.net
[4] Using the Python package `nltk`



(a) Distribution of time of day of screenshot activity across all participants, based on meta data from 21535 screenshots. Screenshot activity peaks around 8pm.



(b) Distribution of apps in the sample.



(c) Distribution of app categories in the sample with more than 1% representation.

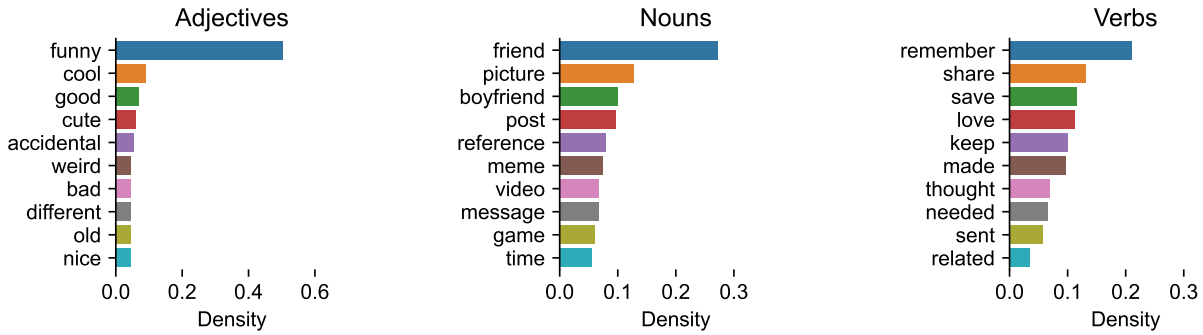


Figure 4: Most common words used in describing the reasoning of capturing screenshots, divided by grammatical function: (a) adjectives, (b) nouns, and (c) verbs.

not unlike a Linear Discriminant Analysis (LDA) [3], but it is the result of a simpler computation, and it is easier to interpret the output as the topics (app categories) are defined beforehand. See the results in Table 3.

Category	*word*	*w*	*word*	*w*	*word*	*w*	*word*	*w*	*word*	*w*	*word*	*w*
browser	fun	0.4	reference	0.3	boyfriend	0.3	post	0.2	remember	0.2		
email	email	0.8	gift	0.6	card	0.6	boyfriend	0.1				
finance	testing	1.0	returned	1.0	mom	0.2	evidence	0.2	proof	0.2	needed	0.1
food	pick	1.0	invoice	0.5	order	0.4	food	0.2	husband	0.2		
gaming	winning	0.8	cry	0.8	game	0.8	made	0.2	love	0.1		
health	challenge	1.0	completed	0.8	trip	0.6	coupon	0.5	made	0.2	remember	0.1
maps	route	0.8	ui	0.5	learn	0.3	bike	0.3	trip	0.3		
messaging	fact	1.0	picture	0.2	love	0.2	post	0.2	friend	0.2	funny	0.2
music	playlist	1.0	listening	1.0	lyric	0.5	song	0.4				
OS	accidental	0.5	photo	0.4	video	0.3	picture	0.2	friend	0.1		
productivity	trading	0.2	name	0.2	book	0.2	comment	0.1				
shopping	possible	1.0	product	0.3	buy	0.3	later	0.2	information	0.1		
social media	meme	0.6	love	0.5	funny	0.5	remember	0.4	picture	0.4	friend	0.3
weather	warning	1.0	radar	1.0	strong	1.0	storm	1.0	weather	0.7	family	0.1

Table 3: Most common distinctive words used in describing the reasoning behind taking screenshots divided by app category. *w* refers to the normalized density of a specific word within that app category, such that 1.0 means that a particular word is only present within that one category.

Table 3 provides a number of insights of the most distinctive language use with direct design implications: based on select application categories, we highlight some of such trends below. Furthermore, brief implications for interactivity are provided; these are discussed in more detail in the discussion section.

Finance. The words used to describe reasons for taking screenshots associated with finance type applications show, among others, intentions related to proofs of financial activity (i.e., *evidence*, *proof*). As screenshots of payment systems, banking applications, or digital wallets are relatively poor legal evidence, financial applications could, based on our findings, consider supporting more user friendly ways to generate adequately certified evidence, for instance upon screenshot initiation.

Food. Distinct word patterns used to describe screenshots of food delivery services indicate sharing information and requests about dinner with a spouse (e.g., *pick*, *order*, *food*, *husband*). Such use cases are by and large supported by screenshots, yet there might be opportunities in designing methods for sharing food delivery information that continuously preserve relevant data disregarded by image formats, for instance, related to delivery time or dietary information.

Gaming. The two most commonly used words to describe screenshots in the game category are *winning* and *cry*, respectively. It follows, that screenshots of games are commonly taken to remember significant wins and losses. As memories in the shape of a screenshot are both hard to find, do not contain readable information about the game it depicts (resulting in non ideal search, accessibility, and organization), it is an unsuited data format to support this practice. It shows that there is potential in designing systems aware of screenshots of games to facilitate such "trophy shelves" to support meaningful memories of game play.

Health. The most distinctly used word to describe screenshots of applications in the health category is *challenge*. This could imply that screenshots of health applications are not mostly intended for logging health progression, as one might intuitively consider, but rather serve competitive functions. Health applications could consider matching functionality with such practices; namely enabling personal goal setting with regards to future health, and to support social 'challenges' of competing together towards a more healthy future.

Maps. Distinct words used to describe screenshots of map applications reveal that such screenshots are intended for route planning (i.e., *route*, *learn*, *bike*, *trip*). As screenshots of maps disable interactivity, such as zooming, panning, communicating traffic density, or inspecting alternate routes, it is arguably a poor data format for storing routes. Based on this observation, map applications could therefore consider improving screenshot captures as an interactive solution for users to store and share routes for later offline use.

OS. The OS app category includes screens that are related to the operating system, such as the lock screen, home screen, settings, etc. The most distinctly used word to describe screenshots from the OS category is *accidental*, showing that many screenshots of the lock screen, in particular, were not taken with intent, yet they nevertheless reside in participants' photo libraries. Consequently, there could be design opportunities for detecting accidental screenshots (of operating system screens) to avoid unwanted accumulation of such data. It should be noted that there are valid reasons for taking screenshots of OS screens; we discuss these in detail in the qualitative analysis.

Shopping. The language associated with screenshots of shopping applications include *possible*, *product*, *buy*, *later*. These indicate that screenshots of shopping applications function as shopping or wish lists. Keeping such information unorganized and in image format (that disregards hyperlinks, item availability, or pricing information) does not seamlessly support the intention behind the screenshot. Consequently, there are opportunities in creating such organized lists automatically based on screenshot behavior.

Weather. Words distinctly associated with screenshots of weather applications include *warning*, *radar*, *strong*, *storm*, *family*: together these indicate that screenshots of weather applications are used to

communicate forthcoming potential dangers to family members. Since screenshots are constant artifacts that do not update as, for instance, weather risks are reassessed, sharing screenshots for this use case is perhaps not ideal; weather applications could therefore consider more user friendly ways to continuously share weather information, even from screenshot initiation.

4.2 Qualitative analyses

The computational analysis considered the most common and distinct reasons for taking screenshots across app category. We were furthermore interested in revealing uncommon practices. Based on the word distributions presented in Table 3, we therefore investigated atypical reasons for taking screenshots. Such practices may reveal design opportunities that the most common practices tend to overshadow in analyses of screenshot use (e.g., sharing screen content with friends).

We extracted reasons for taking screenshots that did not contain the most commonly used words. As an example, we inspected reasons for why people take screenshots of OS applications, that were not described as 'accidental', as was identified as the mainstream reason provided for the OS category. These extracts gives viable information about practices that quantitative analyses or natural language processing will tend to miss. The extracted sentences are of a modest quantity, which allowed us to manually read each one and make sense of these; we list selected findings below.

Lock screen. There are several screenshots of OS related applications, in particular the lock screen (find such an example in the paper's teaser Figure 1). Except for the common 'accidental' reason, there are valid reasons that serve as rich interaction purposes, that are by and large unsupported by the current mobile operating systems.

The first pattern emerging was *time registration*; in particular that the purpose of taking a screenshot of the lock screen was to capture an image of the clock, to have a timestamp mentally associated with significant a external event (e.g., time of a child's nap or of car parking). Another pattern of screenshots of the lock screen related to *sharing notifications* to communicate the reception, rather than the specific content, of particular information.

Photos. Taking a screenshot turns the screen content into an image representation. As content in the photo library is already in image format, the usefulness of capturing screenshots of photos might seem irrelevant. Nevertheless, 11 participants shared 79 screenshots from the photo library in our study, for various reasons. These both relate to organization of images in a chronological library (e.g, "I wanted to screenshot this so it would show up [in the top of the photo library]" or "I wanted to push [the screenshot] to [the] most recent"); but also related to comparing two images, namely that capturing screenshots of two time-distant photos results in them neighbouring in the default view in the photo library, hence enabling seamless swipe between them for comparison.

Additionally, screenshots of photos are captured for the purpose of image processing, such as cropping (e.g., "Cropped the image and used it as a background" or "so I could make a wallpaper") or taking stills of video ("Photo of my wife I screenshotted from a video"). These examples show that using the screenshot functionality for photo editing, even if technically inferior, is a user friendly alternative to existing photo editing software. Consequently, there could be design opportunities in supporting screenshot interaction for instant image processing while preserving image resolution and meta data.

Book keeping. We identified a significant portion of screenshots that relate to book keeping, such as storing invoices for reimbursement, proofs for financial transactions, and otherwise household related documentation such as receipts or order confirmations. Such related documentation is important to store, however, keeping the data unorganized in a photo library poorly supports the intended use (i.e., retrieval, integrations). We identified book keeping as a screenshot motivation across most application categories, in particular browser, email, food delivery, and shopping.

Bypass technical hindrances. A niche use case of screenshots emerged as reading through motivations for screenshot captures featuring uncommon word use. These related to circumventing technical barriers for accessing content. This purpose was identified from making content available offline (e.g., maps, emails); from storing information before a paywall popup would hide content; and from storing content behind security measures (e.g., to access medical records, or citizen data without two-factor identification). These screenshots together show how mobile computing could aid access to content without connectivity, but also that screenshotting as a mobile interaction style affords opportunities in circumventing commercial and security barriers.

4.2.1 Affinity Diagram. To further develop an understanding of the collected data we used affinitity diagramming [25]. We found inspiration from Braun and Clarke's writings about thematic analysis [6]; specifically in their notion of combined inductive and deductive analysis; as in applying a minimal theory-based meaning to collected data although acknowledging prior readings that shape the understanding. We furthermore adhered to common practices of thematic analysis such as using verbatim data (i.e., without cleaning), reading all responses before analysis, and considering a consistent application of methodology.

As a first step, we removed obvious duplicates from the within-participant data (e.g., series of screenshots of identical or highly similar content), to limit the number of physical prints needed for the next phase, with a resulting 1089 entries. To further limit the amount of entries for qualitative analysis, and to not inflate the analysis with similar content, we randomly sampled five screenshots per application. The resulting data set comprised 392 screenshots and their associated textual reasons. We then printed each of these screenshots (cut with scissor from grids of 3×3 in A4 format) with their associated textual reasons printed below. These cards were laid out on a large table in no particular order. The organization of the screenshots proceeded by picking a card from the table, reading the description and looking at the visual screenshot, and then choosing to either place it in an existing theme, creating a new theme, or placing it in the *?* pile. This was repeated until all cards were placed in a theme. We then distributed cards from the *?* pile, and validated themes by going through each pile. We then proceeded by grouping cards in subthemes in the same manner.

Finally, we organized themes and subthemes in a spreadsheet and merged closely related themes. The final organization of themes is shown in the thematic map in Figure 5.

The combination of looking at the actual screenshot and reading the reason for capture, allowed for an interpretation of the participant's meaning with each screenshot that would otherwise not have been possible. There were many such instances where the overlap between image and text allowed 'giving voice' to a participant's experience; exemplified by a screenshot of the lock screen showing multiple unread text messages with affectionate birthday greetings, with the caption "birthday texts". The reason provided, in this instance, conveys the screenshot content objectively, but alone fails to represent the affectionate reason for documenting such a screen, which present qualitative analysis can document.

4.2.2 Themes. Nine themes emerged from our affinity diagram, see below.

Health. People take screenshots of medical information from both online sources and within specific applications. These are stored to have easy access to important information, such as allergies, medical records, or specific treatments; for instance a participant writes about a screenshot of the notes application: *A list of good foods to eat after getting wisdom teeth removed [...]*, or a screenshot of a conversation with a general practitioner with the following note: *To show my husband when his appointment is.*

Learning. Screenshots of learning material is a relative common reason for capturing and storing screenshots. These are oftentimes screenshots of slides from a lecture, stills from a video, graphs from learning material, or exercises from either within a PDF or from online material.

Documentation. The documentation category relates to diverse reasons for capturing and storing important information for later retrieval, such as receipts of purchases, to certify actions (e.g., transfer of money), or to document activities for opening a dispute (e.g., relating to rental agreements or cancellation of purchases). An overwhelming amount of screenshots serve this purpose, and many of the screenshots within this theme closely relate to the theme 'Bookmarks' and its subtheme "in case I need it".

Technical support. In the technical support theme we found diverse reasons for screenshot captures, with use cases in aiding technical features, either not currently present, or not readily available. Such use cases are image processing (e.g., cropping, converting PDF to PNG, taking stills); storing content for offline use (e.g., maps, content behind paywalls); to document operating system settings; and to maintain specific messaging practices such as storing parts of conversations or to forward specific messages. The breadth of screenshot use cases to aid technical features show the need for understanding screenshotting as an interaction style, rather than producing pixel output, and points towards directions for operating system support.

Inspiration and planning. Participants from our study shared many screenshots intended for future inspiration and planning. These were motivated by, for instance, places a participant wanted to visit, such as restaurant or travel destinations. Also, TV show or movie recommendations were identified (e.g., *A video I wanted to watch (but never did) that showed up on my feed.*). The screenshots with such motivations and plans for future activity were captured across many applications, such as maps, Youtube, social media, from food delivery applications and websites. We reflect these diverse plans through four subthemes: 'Tourism', 'Culture', 'Jobs', and 'Food'.

Capturing the moment. A group of screenshots from the sample had reasons related to bookmarking, yet substantially different as their purposes were not given during capture. We theme these screenshots as *capturing the moment*, as the utilitarian value of the screenshot is either limited (or unknown at time of capture), and the screenshot is therefore mostly taken because 'it felt right'. The examples are furthermore divided in three subthemes: 'Aesthetics', 'Frustration', and 'Joy'. Cards placed in the aesthethics subtheme were taken because of their pleasing visual properties. For example a screenshot of the calendar with the reason *It was 2/22/22 so I screenshotted it*, and a screenshot of an abstract painting with the description *I love the pattern*. There were a considerable amount of screenshots in the subtheme 'Joy', such as from game play and archiving happy moments. These motivations are not clearly distinct from the subtheme 'Memories' and its subsubthemes, yet we propose this organization to reflect that reasons provided in 'Capturing the moment' indicated that the motivations were unclear in the moment of capture. Apart from the numerous joyful screenshots we observe some screenshots taken out of frustration. An example of this was a screenshot in the subtheme 'Frustration': a screenshot of a map application showing dense traffic with the provided reason: *It was annoying*. Such content shows, even if uncommon, that screenshots are widely motivated in respect to their valence of affect.

Bookmarks. Screenshots taken for the purpose of bookmarking is the most frequent theme. We identified seven subthemes related to taking screenshots and storing them for later use. These subthemes are not distinct from other themes identified, as motivations occasionally overlap with other themes, yet this theme materialized from reasons for screenshot capture that were motivated by storing information for later (personal) use. The most original subthemes in the bookmark theme were 'On top': relating to screenshots taken with the purpose of appearing as the most recent photos in the photo library for easy retrieval; 'Motivational content': relating to screenshots with quotes or otherwise uplifting spiritual content; and 'Memories': relating to screenshots that document personal meaningful events stored for sentimental reasons (e.g., a map documenting a hike, a realtor's website showing that the owner's house was sold, or birthday greetings).

Shopping. Screenshots related to shopping activity, as already documented through the quantitative analysis, relates to storing products seen from social media, shopping applications, and across websites. The are examples of both products intended for purchase, screenshots of products for comparison with similar products, in addition to screenshots of products already purchased.

Social. Screenshots related to social activities has previously been extensively documented (i.e., [14]). We find that screenshots with social motivations refer to both documentation of social activity (e.g., screenshots of conversations on social media), and miscellaneous content intended for sharing with a friend, or groups of

Figure 5: Thematic map showing themes and subthemes identified from reasons for taking screenshots.

friends. Commonly, such screenshots were taken for immediate use in another mobile application, but tend to continue to reside in participants' photo libraries even after use. Furthermore we identify a subtheme of socially related screenshots that refer to damaging specific individuals' reputation online. This subtheme 'Bullying' to a large extent match what Jaynes identify as *peer surveillance* in studying screenshot use among teenagers [14].

5 DISCUSSION

Previous empirical studies on screenshot practices focus mostly on their social use. We find that social media applications account for less than 40% of overall screenshots, and that reasons for screenshot are much more diverse than motivated for social use; and as a result, many commonplace screenshot practices have so far not been studied. The breadth of use cases uncovered in our analyses, show that

screenshots, both as meaningful experiences, as a style of mobile interaction, as user research, and as digital artifacts have profound implications for mobile computing that provide opportunities for design. We discuss these below.

5.1 Screenshots as meaningful experiences

The experience of *meaning* in human-computer interaction can be understood through five components: connectedness, purpose, coherence, resonance, and significance [17]. Here, we review the components related to meaningful interaction based on findings of screenshot use from our study. Our analysis shows that screenshotting as a mobile interaction style overwhelmingly mediate meaningful experiences as understood through the framework by Mekler and Hornbæk [17].

Connectedness. Many screenshots hold sentimental value, either from capturing significant moments or from relating to affectionate social interaction. Even for screenshots that do not possess any emotional associations, they are seldom taken or live in vacuum: as digital artifacts, screenshots exist beyond the immediate experience of taking them, and hence represent our sense of self through personal beliefs, defining moments, or significant connections.

Purpose. Screenshots serve purposes driven by clear motivations (except when accidentally performed). The reasoning behind screenshot activity is either grounded in expressing beliefs and values, or of personal interests; such as sharing entertaining content with peers, remembering information, circumventing security, or for registering time of important events.

Coherence. Coherence refers to the extent meaningful experiences make sense in relation to life as a whole. In our study, participants, on average, shared 33 screenshots which amounts to about 7% of the screenshots stored in their photo libraries. A small minority (about 5%) of the reasons provided did not encode meaning (e.g., "by accident", "i don't remember", or "no idea"). As as result, the vast majority of screenshots and associated reasons provided deliberate intent. Even as participants could have chosen to skip screenshots that were meaningless, the high fraction of individual and purposeful reasons for taking screenshots indicate coherence in screenshot activity and storage.

Resonance. Resonance denotes the immediate experience of whether something makes sense. A significant amount of the screenshots from our sample indicate that they were taken during a moment of resonance, rather than being planned; this is evident from the amount of screenshots of time limited content (e.g., social media stories), of final game play screens, or for screenshots of content intended to be stored to aid future memory. This way, screenshotting as an activity helps mediate meaningful experiences as its availability fits moments because of feeling 'right'.

Significance. Significance refers to the component of experiences that 'matter'. Most screenshot activity is arguably of limited critical importance (e.g., sharing a meme), yet, they are oftentimes important to the individual, and are kept digitally in large numbers for long times. Their use also indicate critical functions such as financial proof, weather alerts, and negotiating social structures.

5.2 Screenshotting as a mobile interaction style

Previous literature concern screenshots mainly for social interaction [14]. We find that at social motivations for taking screenshots account for less than half of all screenshot captures. Furthermore we find that only 24% of screenshots in our sample were taken with the direct motivation for sharing. In consequence, many, if not most screenshots are taken for other so far poorly understood reasons. We have documented nine themes (including social use) that show the breadth of screenshot motivations. Many of these have substantial representation across applications and participants, yet many of the remaining motivations are mostly idiosyncratic. These relate to a wealth of applications, and they have little frequency across participants. They nevertheless represent important mobile interactions, that enable meaningful experiences, practical functions, and affective memories. We argue that capturing screenshot is a prominent mobile interaction style, that facilitates expressive ways to interact with mobile devices, one self, and peers.

The capture of screenshots has not received much attention from HCI research, although understanding screenshotting as a style of interaction (in terminology by Hornbæk et al. [11, 12]), much like touch interaction, can help address contemporary gaps in design and use of mobile devices and applications. It is evident from our study, that screenshots are seldom taken for their pixel value, but rather represent coherent interaction experiences that are personally meaningful to their peers (e.g., in understanding a clock screenshot as time-taking or a game play screenshot as a digital trophy); and even where the pixels of a screenshot is the preferred output (e.g., in cropping photos), there are opportunities in providing better interactional support, such as instant photo editing options upon screenshot capture of a photo. To that end, placing screenshots in the photo library is inconsistent with their use. As the photograph experienced a shift in value with the emergence of camera phones [21], we argue that maintaining the understanding of screenshots as photos prohibits their interactive potentials.

5.3 Screenshots for user experience research

By crowdsourcing user studies on screenshot use we uncovered a wealth of previously undocumented mobile computing practices across heterogeneous participants and applications. Similarly, designers of mobile applications can use screenshots to extend their understanding of how users engage with their applications. Screenshots for this purpose, can (1) reveal critical missing features that users need, but are left with screenshotting to partially support (e.g., generating certification of financial activity, storing intermediate calculations, or storing trophies of game play); and (2) it can reveal meaningful (both joyful and frustrating) experiences with an application that a designer can use to underpin design intentions. We therefore envision analysis of screenshot use as a type of empirical investigation in user experience (e.g., as a type of usability inspection) that designers and researchers can use as a cost-friendly and ecological supplement to conducting for instance laboratory studies. Positioning screenshots as a type of empirical examination, can expand user experience researchers' with both short-lived pleasurable moments, and lasting meaningful experiences of a particular technology [16].

5.4 Interactive screenshots

Screenshots were once literal photographs of screens for scientific documentation of interactivity [1]. It is evident that contemporary screenshot use is far from the intention as conceived during the 1960's; and considering a screenshot as a type of photo does not support the interactivity it currently affords. Screenshots, from the user's perspective, are seldom intended as a photos (except that they are interoperable), and storing them in an image format in a chronological photo library (together with regular photographs) is an unfit organization for the intended uses. In consequence, the majority of screenshot practices revealed by our study are poorly supported by the current technical implementations in mobile operating systems and applications. Conventional organization of screenshots in users' photo libraries alongside personal photographs, not only dismantle users' reasons for capturing and storing screenshots, but also fundamentally represent a misunderstanding of the very concept of a screenshot in the light of contemporary mobile computing.

Even simple alterations to current screenshot implementations could support current practices, such as storing contextual information (e.g., foreground application, or text from OCR) as meta data. Such data could aid search, organization, and accessibility of screenshots.

We envision a further attempt at providing support for users' motivations for taking screenshots, by designing a novel screenshot format that instead of capturing pixel values, offers app developers possibilities for making interactive widgets that preserve and continuously update contextual information from screenshot capture. Such an interactive screenshot format could alleviate many of the disadvantageous hindrances for interactivity current pixel-based screenshot implementations enforce, and support user stories identified by the present study.

5.5 Limitations

Using crowdsourcing as a means to collect screen shot data and associated explanations allowed us to explore and analyze an ecological and heterogeneous collection of screenshot practices. It has revealed numerous insights on screenshot practices that from a designer's perspective were 'unintended'. We believe that more traditional empirical methods, such as a survey study most likely would not have captured this information (e.g., the specificity of screenshot practices, the amount of accidental screenshots, the report of screenshot meta data). The choice of methodology does, however, pose some limitations. First, the remote participants who participated in the study were allowed to skip specific screenshots they did not wish to share. This was implemented as a courtesy to avoid sharing sensitive or otherwise private information. As a result, some screenshot practices involving apps with such information has not been extensively covered in this paper. We note, however, that a recent report on app use [26] to a large extent reveals a similar pattern across categories (although gaming is considered the most popular type of app, while only the fifth most screenshotted in our sample). Second, while the employed methods allowed us to collect a larger data set than other more qualitative oriented empirical methods; such methods (e.g., semi-structured interviews or focus group interviews) could have deepened our understanding of screenshot practice from asking follow-up question or engaging in anecdotes from screenshots in participants' photo libraries. Based on the diverse practices related to taking and using screenshots we believe that quantity was an imperative factor for uncovering the breadth of how people engage in mobile screenshots, especially from the perspective of viewing screenshots as a type of interaction style. Third, the mobile application we developed to crowdsource data on screenshot practices, was intentionally simple in design and extent, to ease the burden for participation as much as possible. As a result, the qualitative data we collected regarding the practice (and not the actual screenshots) were rather limited, and in most cases amounting to only a few free-form sentences. Furthermore, we limited applicable screenshots to one year prior to participating, to increase the probability that participants could remember the reason for taking a particular screenshots. This entails that the collected data has decreased internal validity, as the study is limited to a particular time in modern computing; possible emphasizing external events co-occurring during this time. A future longitudinal study could alleviate this concern. Fourth, our choice of method most likely had an effect on participation. We only developed the study application for iOS (and hence did not have any Android users). We furthermore recruited on social media with a small monetary incentive. We also required participants to provide unrestricted photo library access, which might have had a negative effect on willingness to participate. Even if the findings showed large variation in screenshot practices, we acknowledge the representative of our sample as a limitation. Last, we envision interactive applications based on the analysis of our empirical study such as an interactive screenshot format. We have, however, not implemented these concepts, and the actual feasibility of implementing the suggested interaction ideas is therefore left for future research to consider.

6 CONCLUSION

Driving by the research question "Why do people take screenshots on their smartphones?", this paper documented the breadth of reasons why people take screenshots on mobile devices. With a crowdsourced study of 52 participants we sourced 1679 screenshots, that were analyzed quantitatively and qualitatively. From the analyses, we extracted eight themes, which expands the commonly held view that screenshots serve mostly a social function. Our analyses point towards several design opportunities for interaction design, such as making screenshots interactive, inferring intent from screenshot capture, and storing further metadata in screenshots. From these findings we argue that screenshotting should be considered, rather than creation of artifacts, as a style of mobile interaction.

7 DATA AVAILABILITY

For privacy reasons, and as some of the screenshots collected contain sensitive and copyrighted information, we have decided against open sourcing the data (e.g., as there are screenshots of private conversations, internet banking, and photo material where consent from the author or the individuals present has not been granted). All analyses scripts, textual descriptions, and meta data are available without reservation at OSF: https://osf.io/4wyfs/.

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