Investigating the Dichotomy of Sharing Practices in Digital and Physical Realms: from Theoretical Overview to Design Considerations

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2. Abstract

Sharing personal digital information online has been a common activity for many years. However, the recent rise of *sharing economy* services has since expanded the set of "things" one can share (e.g., apartments, cars, bicycles, or work tools). How does the sharing of such physical artifacts differ from "traditional" sharing practices of, for example, photos and status updates? This thesis attempts to consolidate the existing body of work on both sharing personal digital content (e.g., social networking) and physical artifacts (e.g., apartment or car sharing), and attempts to identify both commonalities and differences between them. We summarize existing research on diversity of shared content, users' motivations to share, audience management, privacy & trust issues and user experience requirements. Based on this analysis and additional information gathered from 16 semi-structured interviews with both design practitioners and sharing economy domain experts, we formulate a set of 24 design implications for devising novel sharing economy services. Two of which we test in an experiment with 17 participants using eye-tracking techniques.

3. Introduction

3.1. Context

With the advent of social, mobile, and cloud computing, sharing details of our everyday lives online has become a routine for many of us. The wide adoption of social networking sites (SNS), instant messaging services, and personal fitness applications has enabled sharing a wide range of digital content; initially mostly in the form of textual information (e.g., status updates), then increasingly pictures and videos. Today, dedicated platforms allow us to share our personal preferences in music and food, or details of workouts, with wide audiences [Fedosov et al. 2017]. Scholars in various disciplines, from social psychology to consumer research, have highlighted the motivations and the relevance of such sharing for supporting social relationships [Belk 2010; John 2013b; Kennedy 2016]. For example, Nicholas John describes sharing as a fundamental and constitutive activity of Web 2.0 in general, and SNS in particular [John 2013a]. He positions such sharing as a form of speech and argues that it follows an underlying *communicative* logic ("to let the world know") [John 2013b]. Research in Human-Computer Interaction (HCI) has extensively examined such digital sharing practices through designing and evaluating various content sharing systems that support sharing pictures [Van House et al. 2005; Voida and Mynatt 2005], videos [Lange 2007; Rotman and Preece 2010], music [Silfverberg et al. 2011; Voida et al. 2005], location information [Brown et al. 2007; Consolvo et al. 2005], generic files [Sleeper et al. 2016; Voida et al. 2006], and textual "status updates" [Litt and Hargittai 2016; Vitak 2012].

Although online sharing is a widespread practice nowadays, prior research has outlined a number of issues end-users face, such as (a) managing access to shared content [Voida et al. 2006]*;* (b) self-presentation to multiple audiences [Vitak 2012; Voida et al. 2005]; (c) larger concerns of privacy [Ahern et al. 2007; Raij et al. 2011]; (d) trust in a sharing service [Lehmuskallio and Sarvas 2008]; (e) security [Consolvo et al. 2005; Lange 2007]*;* and (f) avoiding information oversharing [Dalal et al. 2008]. A number of research efforts have

suggested different ways to address those challenges, e.g., by reducing user interface complexity, introducing granular access controls mechanisms over shared content, and targeting selective audiences [Lange 2007; Smetters and Good 2009; Voida et al. 2005; Whalen et al. 2006]. However, such solutions were often put in a specific sharing context (e.g. workout communities, media collections at home) and largely non-systemized throughout today's diverse online sharing landscape.

On the other hand, the recent rise of "sharing economy" services now sees people increasingly share *physical* artifacts, such as apartments and rooms (e.g., Airbnb), vehicles and rides (e.g., Uber), and, more broadly, everyday objects (e.g., Peerby). In contrast to the communicative logic of online sharing, John argues that sharing physical artifacts often represents an act of *distribution* [John 2013b]. Prior work has described practices and motivations for the sharing of apartments [Hamari et al. 2015; Ikkala and Lampinen 2014], cars [Bardhi and Eckhardt 2012; Hamari et al. 2015], tools [Light and Miskelly 2015; Taylor et al. 2016], toys [Ozanne and Ballantine 2010], personal devices [Jacobs et al. 2016], everyday objects [de Jode et al. 2012], as well as peer-to-peer service exchanges [Bellotti et al. 2014; Lampinen et al. 2013]. We argue that many of the challenges and issues that are present in digital online sharing are also highly relevant for the distributive sharing of real world artifacts, especially when they have digital representations and/or are mediated by an online platform. In contrast to online sharing, however, distributive physical sharing has received less attention from design research. This gap will become even more apparent once everyday objects become increasingly networked (e.g., the Internet of Things).

3.2. Goals

Our research goal is thus twofold: (1) to better understand current sharing practices of both digital and physical artifacts; and (2) to address common challenges end-users face in those contexts, with a view towards supporting sharing economy services (technology-mediated physical sharing practices). In order to reach the goals we attempt to compare and contrast these two sharing spheres. Our point of departure lies within John's conceptual classification of different sharing practices into *distributive* and *communicative* logics of sharing [John 2013b]. Sharing economy services combine both of these logics: acts of distribution of physical resources, and acts of communication by sharing artifact details and availability through an online platform.

Specifically, we address the following research questions:

1. What are the key design themes that constitute technology-mediated sharing practices?

2. What are the commonalities and differences between sharing digital and physical artifacts?

3. What are the design implications for sharing economy services (i.e. technology-mediated physical sharing)?

We address these questions by surveying previous studies of digital and physical sharing. We have systematically reviewed 87 papers published in major HCI venues throughout the last 15 years. We additionally conducted 16 semi-structured interviews with design

practitioners and sharing economy domain experts to develop a deeper understanding of specific design challenges of such services.

We offer three main contributions:

1. A comprehensive account of sharing practices of both digital and physical artifacts.
2. A mapping of the design space for both physical and digital sharing.
3. A set of design implications for future sharing economy services.

In addition, we provide examples on how to take advantage of the design implications from contribution number 3. In particular, we tested two design implications in laboratory settings with eye-tracking and mouse movement analysis in 17 participants exploring a realistic sharing environment.

As a final note, be aware that when we refer to digital or physical sharing practices (and services), we always imply *technology-mediated* sharing of digital or physical artifacts. Non-digital "offline" sharing (e.g., sharing a power drill with a neighbor) is outside the scope of this work.

4. Methodology

Part of the following work (4.1, 4.2, 4.3 and 4.4) was performed in collaboration with Anton Fedosov and Marc Langheinrich from Facoltà di scienze informatiche, Università della Svizzera italiana in Lugano, Switzerland, in the context of a scholarship provided by said university (www.usi.ch). Part of it was published in the Proceedings of the 10th Nordic Conference on Human-Computer Interaction (ACM; September, 2018).

4.1. Understanding sharing practices: Extensive literature survey

To understand the key design themes that constitute technology-mediated sharing (RQ1), we performed a literature survey across eight broad domains identified in prior art:

1. file sharing,
2. photo sharing,
3. sharing videos,
4. music sharing,
5. sharing in social media,
6. sharing locations,
7. sharing personal biophysical information, and
8. sharing physical artifacts in the context of sharing economy services.

In our study, we aimed to include both seminal and nascent works on sharing within the HCI (Human-Computer Interaction) and CSCW (Computer-Supported Cooperative Work) communities and beyond.

Following a methodology suggested by Dillahunt et al. [Dillahunt et al. 2017], we conducted a systematic literature review of 87 papers to build a data corpus of various contemporary sharing practices of both digital and physical artifacts. The process for

selecting these papers was the following: initially, we identified the most cited papers on "sharing" using both the ACM digital library (http://dl.acm.org) within key conference proceedings (e.g., CHI, CSCW, Ubicomp) and journals, as well as Google Scholar (http://scholar.google.com). Next, we excluded articles that were not aligned to our RQ1, or which had no clear methodology or data collection process described. For the remaining articles, we additionally included studies that cited those works. We then classified articles along two dimensions: the principal medium of sharing (physical vs. digital) and the logics of sharing (*communicative* vs. *distributive*) [John 2013b]. It is important to note that after performing this process iteratively, the studies of digital sharing practices were dominant in our data corpus.

4.2. Building a comparison framework: Data clustering

Next, following Epstein's et al. [Epstein et al. 2015] design framework, we reviewed each paper from the corpus focusing on *what* people share, *to whom*, *why*, and *how* sharing takes place. Two researchers on the team used open and axial coding techniques from Grounded Theory [Glaser et al. 1968] to analyze the data thematically. This is a systematic methodology involving the construction of theory through methodic gathering and analysis of data, where researchers review the collected data looking for recurring concepts, which are tagged with *codes*, and eventually codes are grouped into *themes*. When codes are expected to fall within certain previously known categories, we say we are applying the axial coding technique; the open coding technique is the opposite, where themes are created or discovered during the classification process.

The process was iterative: the team met every week to discuss the emergent empirical categories, going back and forth between the data and the researchers' notes, which we developed through recurrent reading of the material [Miles and Huberman 1994]. Subsequently, we identified 5 top-tier themes and 8 sub-themes that served as our point of comparison between sharing digital and physical artifacts (RQ2).

4.3. Arriving to design considerations: Data analysis

To this end and drawing on content analysis methodology [Glaser et al. 1968], we counted occurrences in our set of papers that corresponded to our coding tree. We then attempted to explain, speculate upon, or suggest ways to study the commonalities and differences between technology-mediated sharing practices of digital and physical realms. In order to do so, we reflected upon previous work bridging digital and physical realms.

Building from these reflections, we arrived to a set of design considerations to improve online sharing services of physical artifacts (RQ3).

4.4. Supporting findings: Semi-structured interviews

To further our understanding of these numerical findings, and to develop a richer account of physical sharing practices, we engaged with 5 sharing economy domain experts and 11 design practitioners (16 people in total) in semi-structured interviews. Participants aged 31.3 years on average (3.6 standard deviation), 11 were female, and had 6.1 years at their current work position, all used sharing economy services actively. We were particularly

interested in recruiting designers and domain experts not only to elicit their personal experiential accounts of participating in popular sharing economy services, but also to collect their professional reflections on developing and running such services. The goals of the interviews were twofold: (1) to better understand nuanced characteristics of contemporary sharing economy services within the previously identified five top-tier themes; and (2) to identify challenges end-users face while interacting with such sharing services to inform the design of future physical sharing services.

We recruited participants through our extended professional networks, and provided 20 dollars gift-cards as thanks for contributing to the research. After collecting participants' demographic information and establishing a common frame of reference around the "sharing economy" phenomena, we then inquired about one sharing economy service that participants have had most experience with. We first wanted to elicit their personal experience with this service, therefore we asked questions such as "Can you describe what have you shared in this platform? Have you had any concerns about sharing this?". We subsequently sought their professional feedback about that service. For example, we have challenged designers: "According to you, what are the key user experience requirements in this platform? How have designers tried to meet them?". For sharing economy experts, we asked: "Can you describe the main motivations to participate in this sharing economy service for both peer-producers and peer-consumers?". For those who had experience running a service we further inquired about the biggest challenges they had faced to establish a new service. Refer to the annex for the full interview protocol. The interviews were conducted using Skype, each of them took about one hour and were transcribed verbatim. We adopted a deductive coding approach [Miles and Huberman 1994] in order to distill a set of design implications for sharing economy services (RQ3).

4.5. Illustrating results: End-user experiment

Finally, we selected two design considerations and performed an experiment to evaluate the effectiveness of our recommendations in a realistic scenario. We developed fictional online sharing services and built a set of sharing scenarios designed to explore different ways to take advantage of the recommendations, we then exposed them to 20 participants (3 were discarded after quality assessment of the data) and studied their responses. Participants aged 27.3 years on average (3.1 standard deviation), 7 were female. All subjects were naïve to the objectives of the experiment, had normal or corrected to normal vision, and provided written informed consent according to the recommendations of the declaration of Helsinki to participate in the study. We analysed their interactions with the platforms according to a set of indicators based on their eye and hand movements. We used a 60 Hz eye-tracker (EyeTribe[2]) to measure gaze position. This eye-tracker consists of an infrared camera coupled with infrared LEDs. The light source is directed toward the eye of the participant, and the camera tracks the reflection of the light source along with ocular and facial features. After a calibration, consisting of following a circle on the screen, the equipment constructs a grid that relates eye-angle with screen coordinates. Then, during the experiment, reflection data is used to interpolate the rotation of the eye and ultimately the direction of gaze. This information is combined with mouse coordinates to assess hand and

[2] http://theeyetribe.com

eye movements on the screen, in pixel coordinates. The experiment was performed in laboratory conditions in order to collect good quality data.

This helped us to understand how end-users perceive and experience particular aspects of the interfaces of sharing services, which illustrates how to put the design considerations to practice and, in turn, provides great feedback for our work.

5. Results and discussion

The results reported below, firstly, describe the 5 main themes and 8 sub-themes that emerged from the analysis; secondly, outline similarities and differences between digital and physical sharing practices; and finally, they inform a set of design considerations for the development of technology-mediated physical sharing practices. In each section, we present illustrative examples that help capture detailed characteristics of contemporary sharing economy services and illustrate their ongoing design challenges using participants' quotes from the interviews. In what follows, we use pseudonyms to describe study participants.

5.1. Technology-mediated sharing practices

In this section we present our progress on understanding technology-mediated sharing practices and the results we got following the aforementioned methodology, and attempt to explain, speculate upon, or suggest ways to study relevant findings.

We begin by providing an extensive literature review, on which we draw to arrive at a framework for *experience design for sharing practices*. We then use this model to frame our comparisons between digital and physical sharing practices. Finally, we build upon found similarities and differences to arrive to several design considerations, specifically for technology-mediated sharing practices of the physical realm.

In what follows, we provide a substantial summary of prior work, which acts as a point of departure for our analysis.

5.1.1. Literature review

Related work falls into three main areas:

1. research in HCI that investigates online content sharing practices,
2. studies of sharing and *sharing economy* services, and
3. intersecting research in interaction design and domestic computing that looks into bridging digital and physical artifacts.

5.1.1.1. Digital sharing practices online

Early work on digital sharing phenomena outlined the practices of file sharing, mainly for supporting group work [Dalal et al. 2008; John 2014; Mannak et al. 2004; Smetters and Good 2009; Voida et al. 2006; Whalen et al. 2006]. Studies described the heterogeneity of various file-sharing methods (e.g., E-Mail, instant messaging, blogs) [Whalen et al. 2006] and classified motivations to share files not only around efficiency and productivity at work [Dalal et al. 2008; Smetters and Good 2009; Whalen et al. 2006], but also outlined social factors characterizing peer-to-peer sharing [Mannak et al. 2004].

Probably the major topic in file sharing research is access control, users forget what files had been shared and with whom [Voida et al. 2006]. Access to files is dynamic, users interact with access controls to update permissions on their files [Whalen et al. 2006], or they move their content to different contexts when they need a shift in audience or privacy settings [Smetters and Good 2009]. This dynamic aspect of file sharing, combined with inappropriate access controls, leads to human error and eventually to over sharing (users granting more access than necessary) [Dalal et al. 2008]. Researchers argue for the need of improved access controls, stating that these should be user-friendly and simple to manage [Whalen et al. 2006; Smetters and Good 2009], and they should make changes easy to perform at an appropriate level of granularity [Whalen et al. 2006], even if this means to limit flexibility in order to simplify use [Smetters and Good 2009].

Later, with a boom of online photo sharing services, researchers started to look at the actual experiences surrounding sharing practices [Van House et al. 2005; Voida and Mynatt 2005]. Self-presentation [Goh et al. 2009; Van House et al. 2005; Silfverberg et al. 2011] and self-expression [Brown et al. 2001; Goh et al. 2009; Van House et al. 2005; Yejean Park et al. 2011] along with the social motives to create and maintain relationships [Goh et al. 2009; Lange 2007; Rotman and Preece 2010] became important factors to motivate digital content sharing. However, digitally stored personal photo, video, and music collections allowed wide, often unknown, audiences to access them [Brown et al. 2001]. Naturally, this aggravated privacy concerns [Ahern et al. 2007; Lange 2007; Miller and Edwards 2007] around proper audience management for shared content [Kairam et al. 2012; Lange 2007; Voida et al. 2005].

Researchers, particularly those interested in photo sharing practices, express that new ways to control audience and privacy settings need to be designed to avoid efforts to the users [Miller and Edwards 2007]. Some authors started addressing this issue [Ahern et al. 2007; Kairam et al. 2012] but the topic is still in its infancy. However, there is evidence on the positive effects of selecting a proper audience for the shared content, sharing selectively could be a strategy to ensure that interested parties see more relevant content and thus engage more [Kairam et al. 2012].

Given that self presentation and identity management are the main motivations that drive users when sharing music [Voida et al. 2005; Silfverberg et al. 2011; Brown et al. 2001; Yejean Park et al. 2011; Håkansson et al. 2007b; Håkansson et al. 2007a], researchers on this topic point out that services should reflect an appropriate image of the user. Again, one way to achieve it could be to build more granular access control tools, through which users could manage others' impressions of them by selecting the proper audience for their content [Voida et al. 2005].

Articles on video sharing distinguish two types of videos being shared: spontaneous and scripted videos. Examples of spontaneous videos could be a short segment of a concert the sharer went to, or shoots of one's friends at a party, and scripted videos are, for example, movie scenes, advertisements, or videos made by 'YouTubers'. This two types of content have many differences, starting with audience and privacy. Most of the times, scripted videos are intended for the general public, and video makers heavily promote them to connect with as many people as possible [Lange 2007]. On the other hand, spontaneous videos are generally targeted to close relatives and friends [Lehmuskallio and Sarvas 2008]. These differences regarding audience, plus diverse user preferences towards revealing their

personal identities, end up making privacy behaviours more complicated. As in photo and music sharing research, authors call for technical features to provide users more granular controls for targeting their content [Lange 2007].

Collectively, these studies on media sharing practices deepened our understanding of *why* people share online. Our work summarizes these motivations and categorizes privacy concerns across different sharing contexts.

Studies in SNS confirm that managing the audience of shared content is one of the key factors in service usage. Acquisti and Gross [Acquisti and Gross 2006] explained the "privacy paradox" – the dichotomy between users' privacy concerns and their online disclosures. Despite concerns, active social network users often reveal large amounts of personal information on SNS. In particular, these concerns neither affect how users adjust their profile visibility [Tufekci 2008] nor their posting behavior on SNS [Reynolds et al. 2011]. Furthermore, previous research identified how people address audience challenges on social media: they think of more general abstract audiences or imagined targeted audiences [Litt and Hargittai 2016]. In fact, these ambiguous audiences in SNS raised the issue of "context collapse", where self-presentation and the distribution of information to distinct social groups (e.g. personal, professional) became difficult: "people from different contexts become part of a singular group of message recipients" [Vitak 2012]. Social media scholars identified several coping mechanisms to address context collapse through boundary regulation [Wisniewski et al. 2012] and audience segmentation [Watson et al. 2012], and concluded that control over the audience to access personal information is critical to address privacy concerns in SNS [Ellison et al. 2011].

These works informed our study articulating *to whom* sharing takes place, emphasizing the audience as a constitutive factor to classify contemporary sharing practices.

With the rapid adoption of GPS sensors on smartphones, people started to share their locations [Wagner et al. 2010] not only with family members (e.g., through specialized apps) but also to strangers (e.g., on SNS), which naturally aggravated issues of privacy and security [Beldad and Citra Kusumadewi 2015; Consolvo et al. 2005]. Furthermore, research pointed out that people can infer one's activity from a shared location and, subsequently, make judgmental conclusions about one's behavior [Brown et al. 2007; Wagner et al. 2010].

Unlike in online social networks, where profile information is shared on a broadcast basis, in location-sharing services users prefer to give explicit consent each time their location is requested [Wagner et al. 2010]. When people receive a location request, they usually go through the following decision process to determine whether they are willing to share and how much: Who is making the request (and how do I feel about that person right now)? Why does the requester need to know it? What would be most useful to the requester? Am I willing to disclose that? [Consolvo et al. 2005].

We leverage the dynamic *context* that location-sharing research revealed as a factor to compare digital and physical sharing practices.

Recent research on personal informatics [Li et al. 2010] discussed emergent digital sharing practices. People share their physical activity data with tracking devices and smartphone apps to motivate themselves [Munson and Consolvo 2012; Toscos et al. 2006], to create and maintain social ties [Consolvo et al. 2006; Mueller et al. 2010; Munson and

Consolvo 2012], to compete with peers [Ahtinen et al. 2008; Ojala 2013], and to get guidance and feedback [Ojala 2013]. Similar to location sharing, the sensitivity of personal biophysical data (e.g., heart rate) raises issues of safety and security, especially when disclosed indiscriminately [Munson and Consolvo 2012; Ojala 2013; Prasad et al. 2012; Raij et al. 2011]. Researchers seem to agree that designing granular, easy-to-use controls over such content would address the challenges of disclosure and thus would improve the sharing experience [Munson et al. 2015; Ojala 2013; Prasad et al. 2012]. Moreover, these studies show that aiming for the right audience leads to a more fulfilling sharing experience, sharing with a specific subset of a community (known or unknown) could generate better responses and reactions.

Epstein et al. [Epstein et al. 2015] introduce a corresponding design framework that is composed of six dimensions: (i) the type of data collected and shared; (ii) the transformations applied to the data prior to sharing; (iii) events that causes the data to be shared; (iv) persistence of shared content; (v) the presentation of the shared data; and (vi) the audience as a recipient of the shared data.

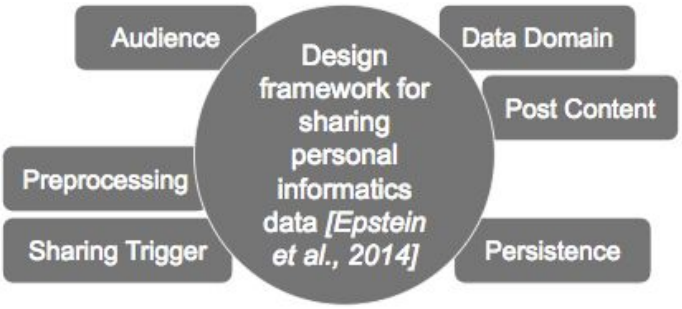


Figure 1 Design framework for sharing personal informatics data

We extend this framework in order to adequately compare and contrast digital and physical sharing practices.

In summary, prior research on sharing digital content online looked at *what* people share, *how* they share, *to whom* they share, and outlined *motivations* for sharing. Note that the aforementioned online sharing practices (with the exception of file sharing) are examples of the *communicative* logic of sharing [John 2017]. Next, we turn to physical sharing practices, where sharing is seen as an act of *distribution*.

5.1.1.2. Physical sharing practices mediated by technology

The recent development of sharing economy platforms and services enabled people to temporarily access and experience underutilized physical resources, such as housing [Ikkala and Lampinen 2014], vehicles [Bardhi and Eckhardt 2012], household objects [Ozanne and Ballantine 2010] and spaces [Taylor et al. 2016]. Researchers empirically illustrated that participation in popular commercial sharing services (e.g., Airbnb, Uber) are often driven by practical needs (e.g., to get a service, increase convenience, receive monetary benefits) [Bellotti et al. 2015; Ikkala and Lampinen 2014]. However, nascent research shows a growing interest in fostering local sharing cooperatives and collectives, such as makerspaces [Taylor et al. 2016], libraries of things [Fedosov et al. 2018; Ozanne and

Ballantine 2010], and community gardens [Light and Miskelly 2015], which prioritize social values over economic gain. Motivations for sharing in the physical realm have been widely studied, Bellotti et al. provide a framework that summarizes them effectively, and identify a mismatch between service providers' design priorities (utopian) and users' motivations (instrumental) [Bellotti et al. 2015]. Similarly, locally-developed initiatives and commercial enterprises in the sharing economy can differ in tone, scale, ambition and practice [Light and Miskelly 2015], in local initiatives the emphasis is on creating shared spaces for collaborative use of resources with joint ownership, whereas in sharing economy services stress is on transformation of resource use, without any social elements [Light and Miskelly 2015]. Researchers highlight a tension between commercial peer-to-peer service exchange businesses and their non-profit counterparts, where earlier free sharing tools (such as Couchsurfing) are disappearing from public awareness, superseded by their for-profit rivals (Airbnb) [Bellotti et al. 2014; Light and Miskelly 2015]. Money seems to provide a frame for the exchange and renders it more formal and structured [Ikkala and Lampinen 2014].

In contrast to digital sharing online, sharing economy services largely adhere to the *distributive* logic of resource sharing [John 2013b]. However, interactive technologies and systems actively *communicate* the availability of those resources on dedicated sharing platforms (e.g., Airbnb) or simply on SNS (e.g., Facebook). Attending to the fact that physical and digital sharing practices may at first glance seem to be semantically different, they not only use similar pro-social rhetoric [John 2017], but also share mutual values of cooperation and participation [Kennedy 2016].

The challenges identified in digital sharing such as access control, self-presentation, and privacy and security concerns, are also present in physical sharing practices. In particular, prior research outlined concerns of trust [Ikkala and Lampinen 2014; Luckner et al. 2015], joint ownership [Light and Miskelly 2015] and reciprocity [Bardhi and Eckhardt 2012; Lampinen et al. 2013] as emergent challenges in physical sharing. Developing trust within a community is a key challenge for designers of sharing economy services [Luckner et al. 2015]. Prior work demonstrated that the sharing of detailed online profiles can contribute to decision-making [Ert et al. 2016] and help establish perceived trustworthiness of a peer [Ma et al. 2017], e.g., when sharing rooms through a sharing economy service. However, it may also entail negative consequences (e.g., racial discrimination) [Edelman and Luca 2014]. We take this into account by incorporating *trust* as a key factor when comparing physical and digital sharing.

Bardhi and Eckhardt [Bardhi and Eckhardt 2012] constructed an analytical framework to describe access-based consumption of shared resources. We include their *temporality* and *consumer involvement* dimensions in our comparison of physical and digital sharing practices. Raval and Dourish [Raval and Dourish 2016] looked at emotional aspects of participation in the sharing economy among Uber and Lyft drivers. We frame these dimensions within the broader concept of *user experience* that influences sharing. Dillahunt and colleagues [Dillahunt et al. 2017] conducted an extensive literature review of the sharing economy in computing and identified several directions for future research. Their work guided our choice of methodology and informed our higher-level themes, namely, *privacy and trust* and *motivations*.

5.1.1.3. Contrasting physical and digital artifacts

Drawing on research in interaction design that looks into bridging personal physical and virtual artifacts (e.g., collections of digital photos, music and movies) in domestic environments [Gruning and Lindley 2016; Munson et al. 2015; Odom et al. 2011; Petrelli and Whittaker 2010], e.g., digital vs. framed pictures, we tried to understand how their sharing practices differ. For instance, studies of personal photography [Frohlich et al. 2002; Nunes et al. 2008] demonstrated that practices created around material forms of media were still present in the digital ephemera. Odom offers an extensive inquiry of "virtual possessions" [Odom et al. 2011]. He contrasts them to personal physical artifacts and proposes three distinctive qualities [Odom et al. 2014]: (i) placelessness – an absence of place where digital things can be found; (ii) spacelessness – they do not intrude into people's physical space and can thus grow invisibly; and (iii) formlessness – the fact that they do not have a clear form, and thus can be easily reproduced, replicated and remixed. The accrual of metadata is another defining aspect of virtual possessions: it supports personalization, linking multiple types of virtual possessions together, and creating social stories [Odom et al. 2013].

Research that investigated virtual possessions in domestic environments provided four insights that distinguish them from personal physical artifacts. First, virtual possessions are fragmented across different services (e.g. desktop, cloud storages, smartphones), which complicates one's sense of ownership [Odom et al. 2013] and control over them [Odom et al. 2012]. Second, digital belongings often lack symbolic associations and lasting value in comparison to their physical counterparts [Petrelli and Whittaker 2010]. Third, the more effortful access to digital artifacts at home [Petrelli and Whittaker 2010] often inhibits serendipitous opportunities for social engagement [Nunes et al. 2008], which physical artifacts allow (e.g., displayed souvenirs and framed photographs). Finally, virtual possessions play a lesser role in identity construction in comparison to personal physical artifacts [Kaye et al. 2006; Lee et al. 2015].

While these studies represent an important point of departure for our work, we note the lack of a shared understanding to describe both differences and commonalities of such cross-domain sharing practices, in order to inform the design of new physical sharing services and platforms. We aim to fill this gap by (i) mapping the design space between physical and digital sharing and (ii) synthesizing a set of implications for design in order to support building future sharing economy services.

5.1.2. Experience design for sharing practices

With the goal of conceptualizing a point of comparison between the activities of sharing digital and physical artifacts, and building on the previous literature review, we present a framework to describe sharing practices, with particular focus on experience design, as it is the core of this work.

We identify 5 top-tier themes and 8 sub-themes that serve as our point of comparison between sharing digital and physical artifacts. We call these themes the *dimensions* of the framework.

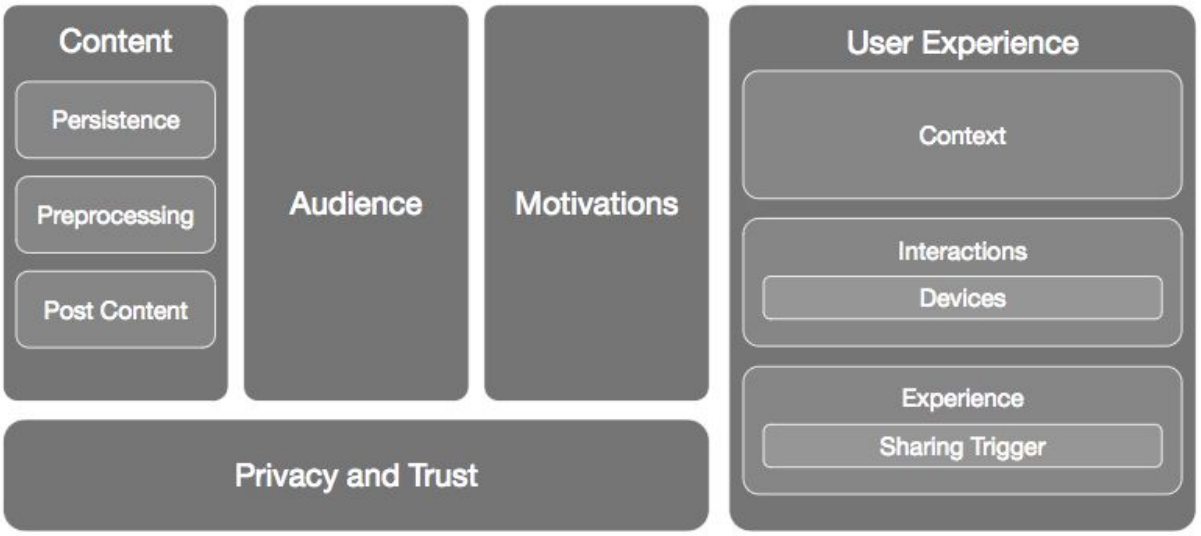


Figure 2 Sharing dimensions emerged from the analysis

- *Content* refers to the type of the shared artifact. It addresses the question: “What is being shared?”
- *Persistence* refers to the lifetime of an artifact. It addresses the question: “For how long is a shared artifact visible or available?”
- *Preprocessing* describes the amount and the type of work done on the content prior to sharing it, and outlines how much a platform assists in performing these tasks. It addresses the question: “Which transformations are being applied to the content before sharing it, and have they been carried out automatically by a system or manually by its users?”
- *Post Content* refers to the format of the shared information. It addresses the question: “What form or shape does the content take in order to be shared?”
- *Audience* refers to the recipients of the shared content. It addresses questions like “To whom is the content being shared and how is it being communicated?”
- *Motivations* are what drive people to share. It addresses the question: “Why is the content being shared?”
- *Privacy and Trust* relates to people’s desire to control information dissemination. It addresses questions like: “How do users feel about privacy and trust issues when deciding to share, and how does it affect their choices?”
- *User Experience* concerns aspects of a user’s internal state, the characteristics of the interaction, and the context where the interaction between the user and the system occurs. In addition to those upper-level categories, we also explore two sub-themes: *devices* that support sharing, and *sharing triggers* that initiate an interaction.
- *Context*, *Interactions* and *Experience* examine how users share, and how they experience the activity. They address questions like: “What are the circumstances in which they are involved?” and “What is the state of a user before, throughout, and after using a sharing service?”
- *Devices* refers to the type of an electronic device that supports sharing. It addresses the question: “What devices are used to collect and to share the information or artifact?”

- *Sharing Trigger* describes the event that initiates a sharing instance. It addresses questions like: “What causes the information to be shared?” and “Is it automatically or manually shared?”

In the following sections, we build over this framework to outline similarities and differences between digital and physical sharing practices. As this is our point of departure and the framework pretends to inform experience design, the final design considerations for online sharing services, at which we are going to arrive later, will to be clustered among these dimensions.

5.1.3. Communicative and distributive sharing practices

Scholar Nicholas A. John studied sharing practices of both material and immaterial things, and the impact of modern online sharing practices in society. He even analysed the evolution of the word “sharing”, and argues that, nowadays, the term is used to describe the activities that constitute participation in Web 2.0.

One of the most interesting aspects of his research, at least for the purposes of this work, is the distinction he makes between *distributive* and *communicative* logics of sharing. The former occurs when the activity requires to divide (or distribute) an object, where one of the participants ends up with less of that object, and the other one with more of it. The latter involves expressing (or communicating) feelings or emotions. Contrary to distributive logics of sharing, this one is not a zero-sum game.

We acknowledge and support John's findings by classifying each one of the papers in our data corpus according to this distinction. We believe several sharing activities have components of both logics, specially in technology-mediated physical sharing practices (e.g., in sharing economy services), however previous research may not recognize it. We attempt to inform how the researchers are addressing their studies related to sharing practices, the questions we ask ourselves in order to classify an article are: “Do the authors acknowledge a distributive logic of sharing in the practice they study? Do they consider any communicative aspects of the activity?”.

The following figure presents an overview of the publications in our data corpus. Note that some articles cover multiple dimensions, hence the final count is greater than 87.

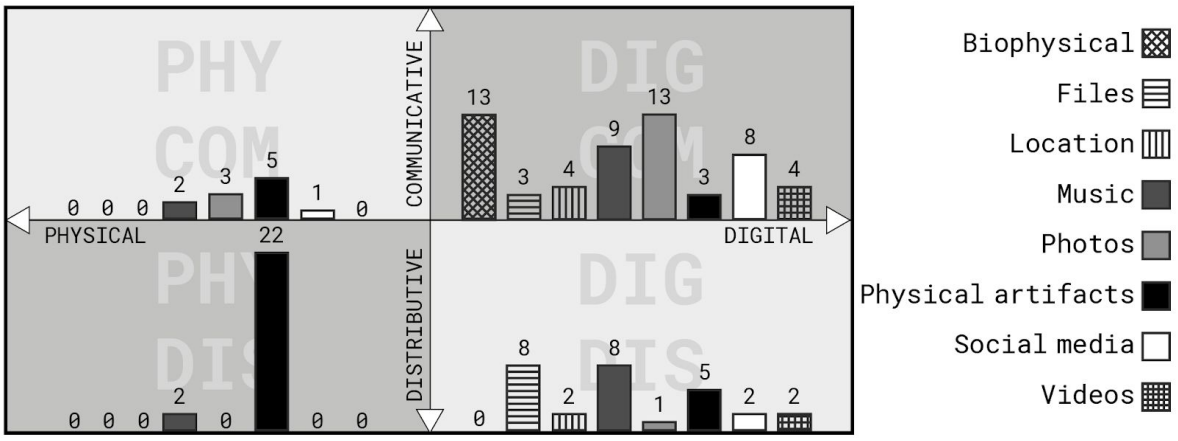


Figure 3 The overview of our data corpus; each paper is classified within digital and physical mediums where sharing occurs, and communicative and distributive logics of sharing; the detailed list is hosted at https://doi.org/10.6084/m9.figshare.6960509

Examining the chart we can see, for instance, that file sharing is mainly a distribute and digital practice, that social media and sharing biophysical information are digital and communicative forms of sharing, and that sharing in the physical realm is mostly distributive. We can also perceive that there is not much research done looking at sharing physical objects as communicative practices. A good example of such practice is sharing printed pictures, which is the focus of some of the few papers in the top-left quadrant. Further research is needed to understand if this means that sharing physical objects is mainly a distributive practice, or if their communicative aspects are not getting the attention they deserve by current research and services.

The following sections will examine this data corpus, reflect upon it, and arrive to several conclusions. One of the potential flaws of working with a meta-research approach is that the composition of the data corpus may bias the analysis. Because of that, it is key to describe the nature of the articles that compose it. The previous chart fulfills this need.

For the rest of the work, we will acknowledge this distinction and keep in mind the distribution of it over the corpus. We will take care of both communicative and distributive logics of sharing.

5.1.4. Digital and physical sharing practices

In this section we exhibit the results of clustering the collected data into several categories, for each dimension of the framework. We display the categories we found in the process, along with their occurrence counts for each sharing realm (digital and physical).

For every dimension, we choose the most relevant findings and attempt to explain or speculate upon them. If possible, we also support these findings with quotes extracted from semi-structured interviews with designers and domain experts.

In summary, this section presents commonalities and differences between digital and physical sharing practices, following the guidelines defined by the previously described framework. Collectively, these reflections not only outline the intricate boundaries of physical

and digital sharing by mapping out the space for researchers in the area, but also establish frames of reference for designers who are working on sharing economy services.

5.1.4.1. Content

We clustered content following two distinctions. The first one is about materiality, where we have three categories: (i) *material*, (ii) *immaterial: concrete*, and (iii) *immaterial: abstract*. The second distinction is its type, which can be one of the following five: (i) *disclosure*, (ii) *file*, (iii) *thing*, (iv) *service*, and (v) *non-revealing information*.

Material objects of sharing have a physical presence. *Immaterial: concrete* content is not material, but can be described as having a concrete form (like digital files). *Immaterial: abstract* types of content have no physical form, and also don't have a concrete existence (for example, knowledge).

Disclosures involve information that could be sensitive or revealing, such as status updates, messages, interests and accounts. *Files* can be, for example, digital pictures. *Things* are physical objects, such as houses, cars and devices. *Services* include labor and assistance. *Non-revealing information* refers to knowledge and skill sharing, for instance.

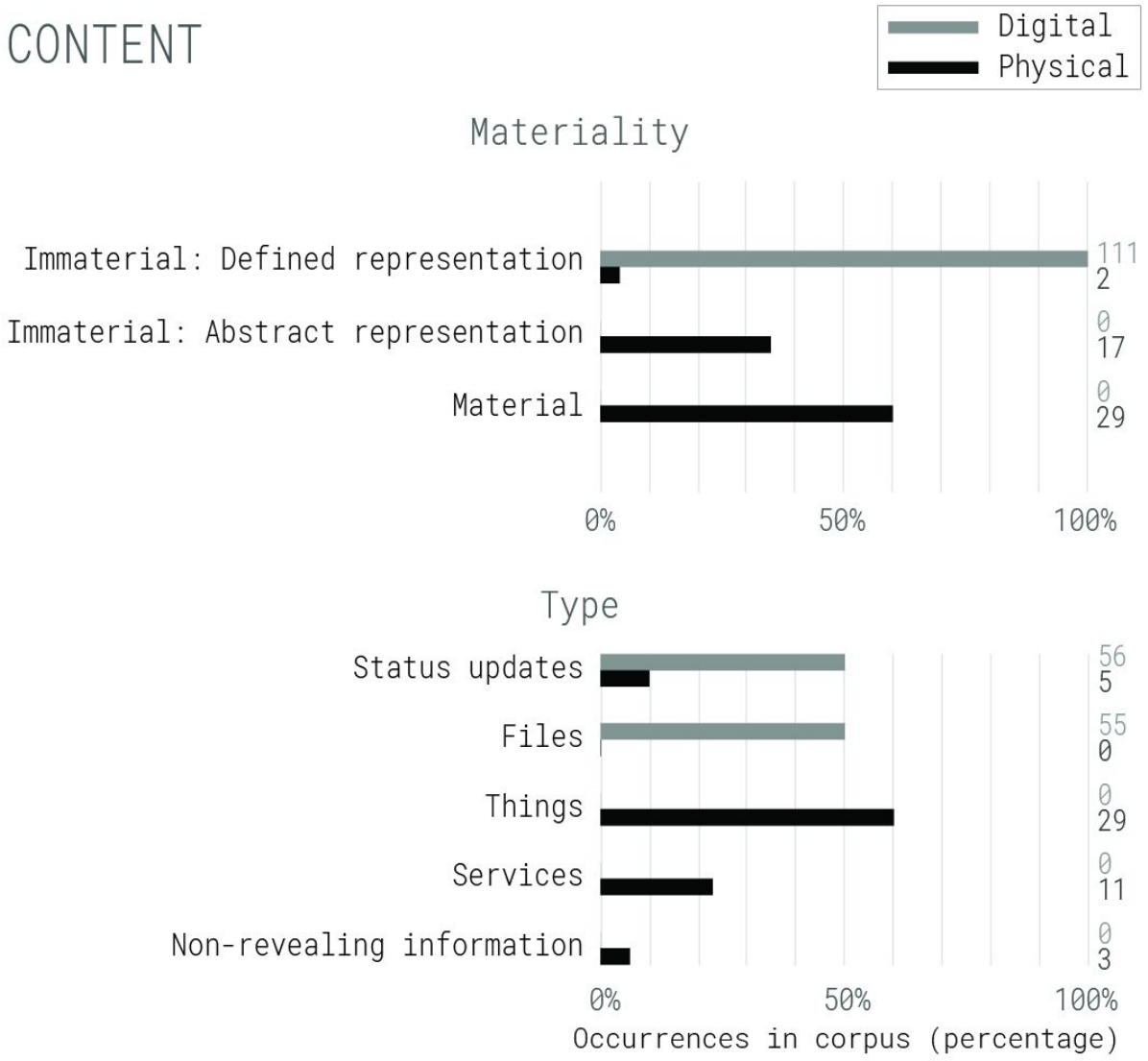


Figure 4 Properties of shared content (digital vs. physical practices)

The content analysis shows that digital content is *immaterial and concrete*, and that physical objects of sharing are *material* in first place, *immaterial and abstract* in second place, and *immaterial and concrete* in just a few cases.

In reference to the type of content, digital objects of sharing are *disclosures* and *files*, and physical items are mostly *things*, followed by *services* and, lastly, by *disclosures* and *non-revealing information*. *Things*, *services* and *non-revealing information* are not present in the digital realm, and there is no evidence of *file* sharing in the physical environment.

Sharing digital information involves only **immaterial content with defined representation**, usually files in the form of digital imagery and status updates in social media or in instant messaging apps. In physical instances of sharing, **material artifacts** are the most frequently shared, followed by **immaterial content with abstract representation**, such as services. Julie (female, 27 years old) pointed out that Airbnb since extended their offerings to different types of services: *“Airbnb launched other kind of products besides*

accommodation, they are expanding the things they offer. It's a new category called 'experiences' where you can find other stuff, not houses, you can book tours, excursions, dinners, maybe even a yoga class at the Himalaya, it's a different type of content". Material artifacts include houses, cars, personal goods, electronic devices, and their digital representations. Worden (male, 32 years old) also explained the diversity of content shared using Airbnb: *"On the one hand it is a physical space that is being shared that makes a flat or house accessible, or the room within a flat, on the other hand it is the whole data layer about the users themselves and the byproduct of their interaction with the platform"*.

The categories of **files**, **disclosures**, and **non-revealing information** are not largely represented in the physical realm. Definitely, there is digital metadata related to the physical objects being shared (such as announcements, owner data, etc.), however the practice of sharing these type of content is not widely studied. Metadata of physical objects could be a valuable possession, as it is in the digital realm [Odom et al. 2011], and augmenting physical items with digital content may enhance their emotional value [de Jode et al. 2012]. Building on top of the nascent research in HCI to "connect" physical artifacts with digital metadata [Benford et al. 2016; de Jode et al. 2012] future research should further explore the sharing practices of digital metadata around the main physical object of sharing, and opportunities for improvement.

On the other hand, future research might explore how to augment digital content with **material** qualities, and how 'material digital content' would be received by users. Files could age, patina may grow over old content and, in extreme cases, files may be fragile and even break. Despite inexpensive cloud storages these decisions may change people's behaviour towards their files and digital archives, users may have to revisit and reflect upon collections, maintain or purge old files, and they could also start thinking about the content and the sizes of their archives (as they do with their physical possessions, for instance during spring cleanings or prior to a garage sale, where they also get rid of old things that are no longer useful). By incorporating these material aspects of physical objects into digital content, services may enable users to reflect on their previous and current selves [Odom et al. 2013], provide better ways to self-present supporting visualizing changes on tastes, and encourage revisiting collections in order to engender positive emotions [Petrelli and Whittaker 2010]. In turn, these could help users in organizing their inventories [Petrelli and Whittaker 2010] and make them aware of the virtual possessions they own [Odom et al. 2012].

5.1.4.1.1. Persistence

We grouped types of persistence in two high level categories: (i) *limited duration* and (ii) *everlasting* (i.e., without an end), and, building on Epstein et al. 2015 [Epstein et al. 2015], we clustered data into three categories detailing into the limited duration type: (i) *temporary*, (ii) *for the lifetime of the system/social network*, and (iii) *for the lifetime of the relationship*.

Temporary includes sharing practices that are ephemeral in time or where the sharer can remove the content. *For the lifetime of the system/social network* regards to sharing for a period of time determined by the presence or existence of a service. *For the lifetime of the relationship* is about sharing until a relationship ends, for example in the domestic environment.

Figure 5 Persistence of shared content (digital vs. physical practices)

The content analysis suggests that both realms are governed by sharing practices of limited duration, although there are instances of sharing with everlasting persistence in the physical realm.

The details into the limited duration persistence type show that the digital environment is primarily ruled by systems' or social networks' lifetimes, whilst the sharing of physical objects is mostly temporary. In second place are the categories of temporary in the digital realm, and for the lifetime of the system/social network in the physical one. Lastly, for the lifetime of the relationship has one occurrence in the physical realm and none in the digital one.

The main difference between realms in this dimension is that people sometimes share physical objects **everlastingly** [Light and Briggs 2017; de Jode et al. 2012; Light and Miskelly 2015], a practice that is not present in the digital environment. This type of persistence refers to changes in ownership, some examples are gift-giving, donations, and crowdfunding. Then it is understandable for this category to be empty in the digital realm, because virtual possessions don't require transfers of ownership, they can be duplicated

[Odom et al. 2014]. Although is important to mention that, in the digital realm, every instance of sharing could be 'transformed' into an everlasting one by the receiver, there is usually some way (maybe 'hacky') to copy and save the current state of a digital item, which complicates the sense of ownership [Odom et al. 2013].

While both sharing practices can be time-constrained, the enforcement mechanisms can be different. For instance, most digital instances of sharing can be **regulated by a system's capabilities** [Lin et al. 2006; Curmi et al. 2013; Munson et al. 2015; Ames et al. 2010; Olsson et al. 2008; Kairam et al. 2012; Silfverberg et al. 2011; Rotman and Preece 2010; Litt and Hargittai 2016], such as the maximal display time of a piece of content on top of the personal timeline in a social media platform. In contrast, the practice of sharing physical artifacts is frequently **determined by a sharer** [Bardhi and Eckhardt 2012; Light and Miskelly 2015; Ozanne and Ballantine 2010; Ikkala and Lampinen 2014], such as in the case of renting apartments through Airbnb, as illustrated by Julie (female, 27 years old): *"Some [flats] are available for immediate booking, but on others you have to indicate you are interested in booking the place and the host evaluates it, and you exchange comments or messages with each other [to reach an agreement]."*

5.1.4.1.2. Preprocessing

Preprocessing tasks were distinguished in three high level categories: (i) *manual*, (ii) *automatic*, and (iii) *raw* (i.e. no preprocessing). Building on Epstein et al. 2015, manual tasks were clustered in five types: (i) *naming and tagging*, (ii) *grouping and linking*, (iii) *adjusting*, (iv) *editing*, and (v) *maintenance*; and automatic tasks were grouped in three categories: (i) *aggregation*, (ii) *naming*, and (iii) *locating*.

Naming and tagging is about identifying data and captioning it. *Grouping and linking* refers to putting together different objects of sharing, such as in albums or playlists, or linking physical objects to digital content. *Adjusting* tasks are about selecting audiences, access rules, granularity, and other settings. *Editing* is about audiovisual transformations of data. *Maintenance* regards to taking care of the shared object.

Aggregation refers to the clustering of data, such as determining goal achievements or daily totals in workout data sharing. *Naming* is the automatic equivalent of the manual task of identifying data. *Locating* is about getting geographical positions.

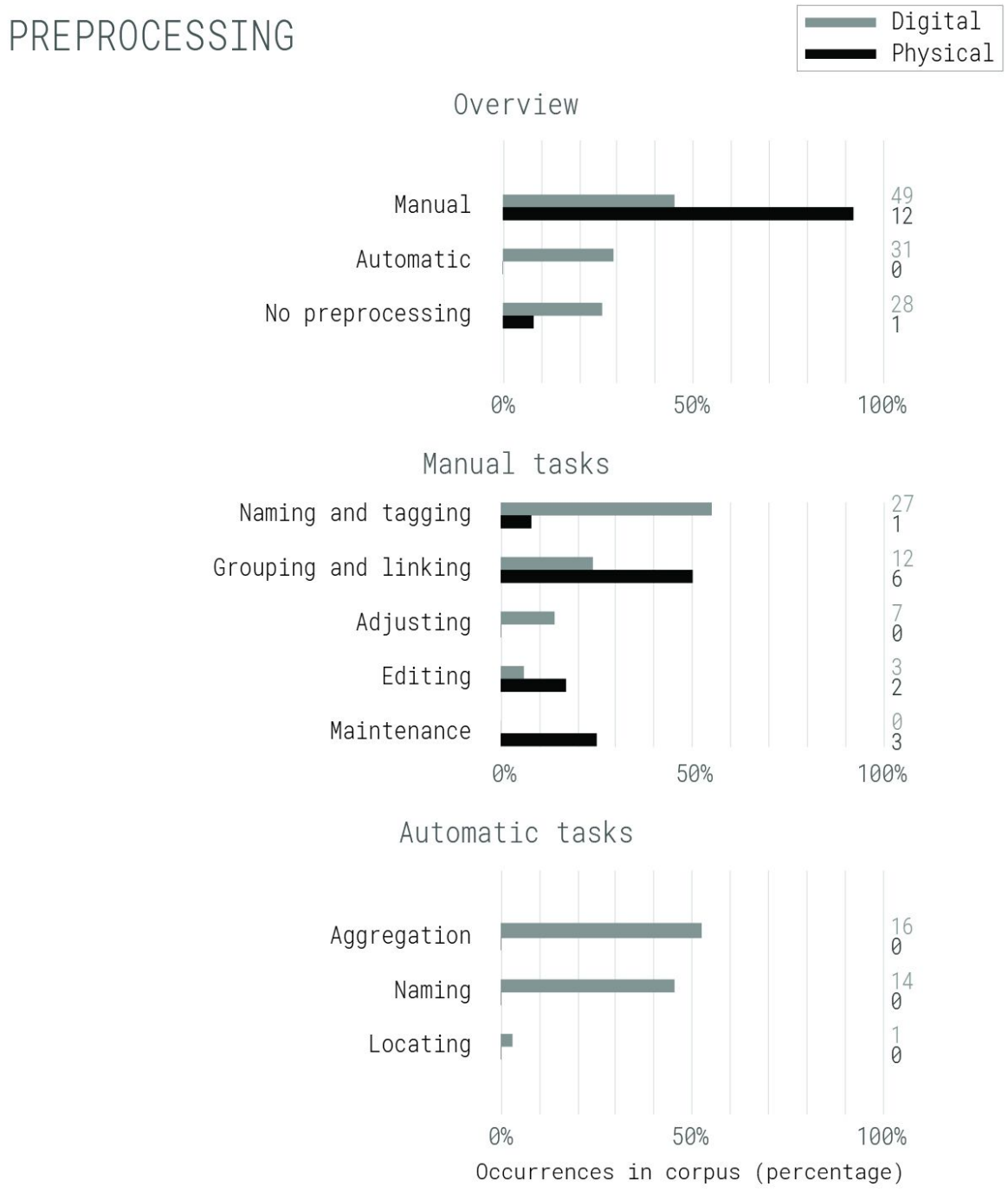


Figure 6 Kinds of preprocessing tasks in sharing practices (digital vs. physical practices)

The content analysis suggests that preprocessing tasks are manual most of the times, in both realms. There are automatic forms of processing in the digital realm, however we found no evidence of them in the physical environment. Both realms contain examples of data being shared without any preprocessing.

Within manual types of preprocessing, *naming and tagging* is the most frequent one in the digital realm, followed by (i) *grouping and linking*, (ii) *adjusting*, and (iii) *editing*, respectively. The category of *maintenance* is not represented in this realm. The most relevant category in the physical realm is *grouping and linking*, followed by (i) *maintenance*, (ii) *editing*, and (iii)

naming and tagging, respectively. There are no cases of *adjusting* tasks in the physical environment.

The different types of automatic preprocessing are represented just in the digital realm, where *aggregation* is the most important one, followed by *naming* tasks. Lastly, the category of *locating* is the least represented.

There looks to be a large amount of **manual** preprocessing work in the physical realm, there are no automatic tools to accomplish the most frequent tasks, such as grouping photos in albums, announcing properties or cars for lend, or performing maintenance (e.g. cleaning). Pierre (male, 37 years old) listed a few manual tasks to find a companion for a ride: *"The app is not the main communication tool after you establish a contact with your passenger, I used SMS, phone or another messenger to sync on certain details. The service did a great job to find a travel buddy. Basic conditions were agreed within the app: I tried to get people who speak the same language, but small details were arranged on the phone... at 5am I prefer to call the person directly to confirm the pick-up"*. These all require human effort. This is not the case when one shares digital content, services usually provide automatic features to relieve burdens, such as aggregating totals, summarizing data into trends, or naming of data.

In our data corpus we observed a prominent difference in the type of manual preprocessing that takes place in physical and digital sharing. For example, the main form of manual processing in the context of photo-sharing is related to **naming, tagging and captioning** pictures [Consolvo et al. 2006; Munson and Consolvo 2012; Ames et al. 2010; Olsson et al. 2008; Ojala and Malinen 2012; Kairam et al. 2016; Voida et al. 2005; Lange 2007]. With physical artifacts, common tasks are instead related to their **maintenance** [Bardhi and Eckhardt 2012], **grouping and linking** supporting digital content [Frohlich et al. 2002; Lampinen and Brown 2017; Benford et al. 2016; Jacobs et al. 2016] (e.g., making announcements or creating albums), as well as **editing** it. Danny (male, 31 years old) recalled his recent experience with Airbnb: *"Sometimes the owners do a good job in describing the place with text and pictures. Sometimes those pictures are too good, I think this [indicates that] something could be wrong with the property, if the pictures have being photoshopped or they used wide-angle cameras... if the text is too well-written"*. This observation suggests that an overly polished description may be interpreted as suspicious or non-reliable.

Another relevant difference regarding to the type of manual preprocessing taking place in each realm is that tasks in the digital domain (naming and tagging) are not as complex and time consuming as those in physical practices (grouping, editing and maintenance).

Petrelli & Whittaker 2010 [Petrelli and Whittaker 2010] compares the effort of organizing digital and physical mementos, they state that digital mementos require more work and, although physical objects also need some commitment, performing organizational tasks with them is more pleasant.

Future work might explore, then, if the fact that the physical environment demands more manual work is a benefit or a hindrance for sharing in this realm. Researchers could try taking away some processes from an existing sharing practice, for example including a third party service to wash one's car before sharing it, thus relieving maintenance responsibilities.

Nunes et al. 2008 [Nunes et al. 2008] points out the importance of fragility when sharing physical objects, participants of their experiment expressed concerns about their mementos breaking because they needed to move them around to share them. If people take into consideration the fragility of things, then it is natural to think that they will also mind to maintain them. We have seen that maintenance tasks are significant in the physical environment.

The category of **maintenance** is present only in the physical realm, digital possessions don't seem to need maintenance, at least prior to sharing. This is due to basic qualities of physical and digital items, physical objects deteriorate and break, whilst digital possessions are generally pristine, thus lack of characteristics such as aging or deterioration.

5.1.4.1.3. Post Content

Post content is the actual form of the content being shared, for example when we say some user is sharing workout data, that person is probably actually sharing text, numbers, graphs, and maps. This dimension was clustered in five categories, building on Epstein et al. 2015, these are: (i) *virtual possessions and media* (e.g., files, pictures, video, audio, etc.), (ii) *text*, (iii) *graphs, summaries and others*, (iv) *services and teaching*, and (v) *physical objects*.

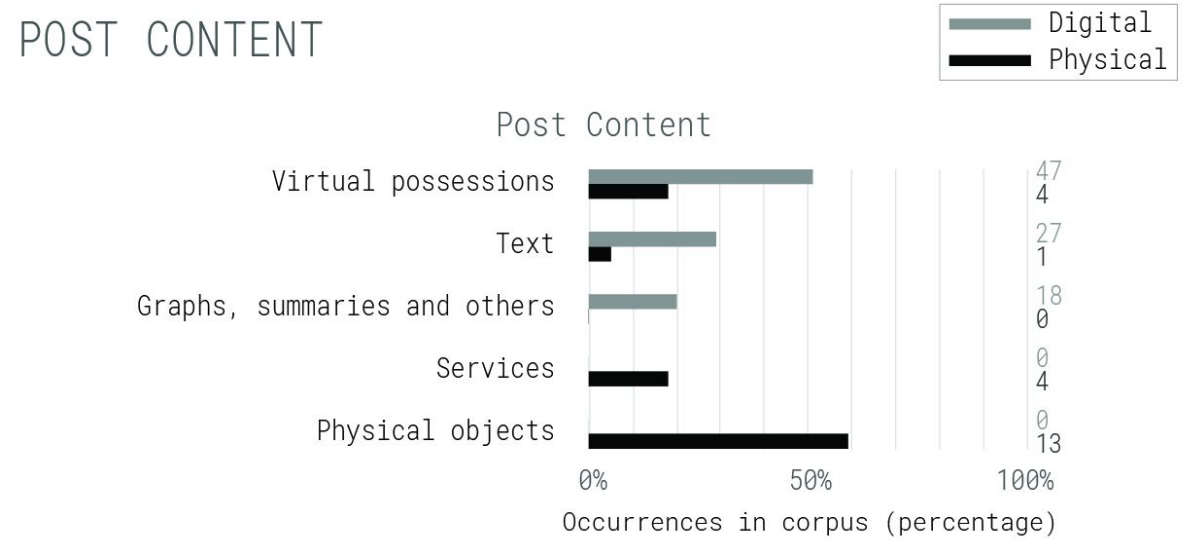


Figure 7 Forms of post content being shared (digital vs. physical practices)

The content analysis shows that digital content is mainly posted as *virtual possessions and media*, followed by *text* and lastly by *graphs, summaries and others*. On the other hand, physical items are shared as *physical objects* in first place, as *virtual possessions and media* and *services and teaching* in second place, and finally as *text*. There are no instances of *services and teaching* or *physical objects* in the digital realm, and of *graphs, summaries and others* in the physical one.

In the digital sphere, people not only share virtual possessions such as images or music, but also digital information *about* real-world events, such as free-form status updates and contextual activity information, such as workout summaries or GPS tracks. Sharing of physical artifacts or services, for example home repairs, IT support, or tutoring, always involves such digital descriptions about an object (e.g., an address where it is located) or a

service. Note that while in some popular platforms, including Airbnb, the content of those listings are carefully curated, Jehanna (female, 31 years old) mentioned that information does not even need to be explicitly advertised at all in order to get a service, like a city tour: *"I got in touch with another Couchsurfing user who didn't offer his house, instead he offered a tour of the city. That's another way to use Couchsurfing, users don't necessarily need to offer their houses, they may offer social encounters. I met this guy who paints, I was interested because I paint as well, it was a good experience, he took me to dance salsa, he showed me his studio, and told me facts about the city, we shared a one day experience."*

Although we acknowledge similarities between both domains, these categories seem to be largely different among both digital and physical realms. Further research is needed to explore each category, its characteristics, how are they received by the audience, and what emotions or responses they trigger. Future research might explore if it is possible to even the numbers, sharing each type of post content in both realms, and how would that impact on the users' experience. Researchers might attempt to answer these questions, for example building mixed scenarios, such as sharing status updates in a physical form (like letters), or exploring the extent to which services can be shared in a digital format.

5.1.4.2. Audience

We clustered audiences following two distinctions. The first one is a relationship scale, which consists of five categories: (i) *oneself*, (ii) *friends and family*, (iii) *acquaintances/extended circles*, (iv) *activity/interest/experience communities*, and (v) *general public/unknown people*. The second distinction is related to breadth and has two categories: (i) *individuals (one-to-one)* and (ii) *groups (one-to-many)*.

Oneself involves sharing to improve accessibility to one's possessions. *Friends and family* regards to close relationships. *Acquaintances/Extended circles* involve distant relationships, such as those with co-workers, classmates, or friends of friends. A*ctivity/Interest/Experience communities* refers to social groups related to one's hobbies, religion, and other activities. *General public/Unknown people* is about sharing with strangers.

An example of sharing to *individuals (one-to-one)* is photo sharing through instant messages. Examples of sharing to *groups (one-to-many)* are status updates in SNS, peer-to-peer file sharing, uploading videos to YouTube, and sharing at makerspaces.

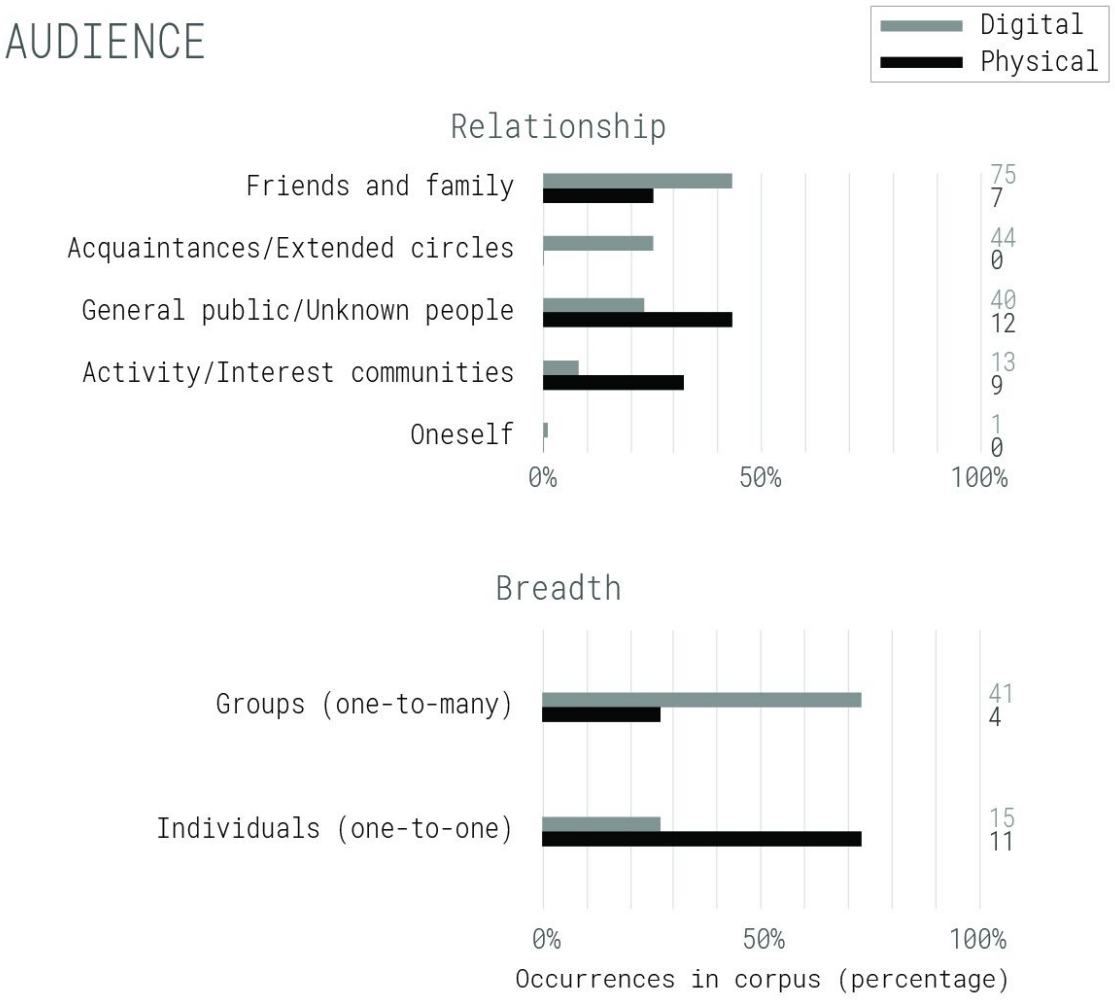


Figure 8 Audience of a sharing practice (digital vs. physical practices)

The content analysis suggests that users share digital items primarily with their friends and family, and physical objects mainly with unknown people. Extended circles and general public are in second and third place respectively in the case of digital content, and activity communities and friends and family in the case of physical objects. There is no evidence of sharing with the extended circles in the physical realm, and activity communities are less represented in the digital environment. From our sample we have observed only one instance of sharing with oneself in the digital realm (through email, or uploading files to online services, but also by transferring data directly to other devices) and none in the physical one.

In the digital realm, users share their content to many people simultaneously, unlike in the physical environment, where the sharing mostly takes place between two individuals, the sharer and the receiver.

In our data, we found a visible difference between digital and physical sharing: most instances of digital sharing are targeted towards friends and family or with their extended circles, which include co-workers and classmates. Conversely, physical sharing practices in the sharing economy typically target unknown people. While sharing physical artifacts (e.g., tools) sometimes happens within interest groups such as makers, Morten (male, 33 years

old) criticizes the lack of community when interacting with a typical sharing economy platform: *"Airbnb somehow seems like making a strong connection between an owner of the apartment and the user, but currently it misses the community dimension between users who rent those apartments."*

It is natural to think that users choose their audiences based on their motivations to share. We will see that the physical realm is governed by exchanges, people want to get something in return, this may explain why the main audience is **unknown people** [Lampinen et al. 2013; Ikkala and Lampinen 2014; Ozanne and Ballantine 2010], one does not need to share with **friends or family** to fulfill these purposes, even more, asking for a payment to a close relative is not something that people want to do, and could be frowned upon.

Similarly, in the next section we will see that motivations in the digital environment are built around maintaining social relationships, which again provides a good understanding on why digital content is shared with **friends and family** [Consolvo et al. 2006; Toscos et al. 2006; Munson and Consolvo 2012; Frohlich et al. 2002; Van House et al. 2005; Ahern et al. 2007; Komulainen et al. 2010; Lehmuskallio and Sarvas 2008; Voida et al. 2006; Reynolds et al. 2011; Consolvo et al. 2005] more frequently than with the **general public**. Another relevant factor to understand why the general public category is less significant in the digital realm is related to privacy issues, the content itself may be too sensitive to be shared with unknown people, as we will see in later sections.

Although there are examples of physical sharing with more than one receiver (such as the sharing of tools, or spaces), most of the time people share to one **individual** at a time. It is because of a basic quality of the physical objects that people usually share (such as tools, books, money, etc.), they can't be used by several individuals at the same time. Digital content is different in that sense, it can be reproduced and spread [Odom et al. 2014], thus it is possible to share it with **multiple users** simultaneously, and it seems that people take advantage of this feature of digital content. We believe this is another substantial difference between digital and physical sharing practices.

When it comes to communicating the information about the shared artifact or service, Dacie (female, 35 years old) emphasized the importance to involve multiple stakeholders to support a transaction on a sharing economy platform. Especially when their involvement is crucial to the outcome of that transaction: *"I had an excellent experience communicating with our host (Lilly). However, since she is not fluent in English she has to ask her daughter to reply [to our messages], so there was some waiting involved in the process (half day or a day). [The platform] may also CC our conversation to her daughter [in order] to get her involved directly."*

In the digital realm people share a significant amount of data with their **extended circles**, which include, for example, co-workers and classmates [Vitak 2012; Wiese et al. 2011; Litt and Hargittai 2016; Goh et al. 2009; Tufekci 2008]. However, this is not the case in the physical environment.

Besides specific motivations for sharing (such as to perform tasks at work or to look for a job), people don't usually target their extended circles as a main audience. Nonetheless, one's extended circles are generally part of the larger network that receives one's shares, which also includes, for instance, friends and family. The amount of instances in the category of acquaintances/extended circles could be explained by the concept of context

collapse, which states that people from different contexts are becoming part of a singular group of message recipients.

Surely people also share physical objects at work or at school (like tools, document papers, information, knowledge, etc.), however, at least to our knowledge, there is no research in reference to these practices. What indeed has been studied in the physical realm is sharing practices within local communities and hobbyists groups [Bellotti et al. 2014; Taylor et al. 2016], which explains the size of the category of **activity/interest/experience communities** in the physical realm. Delora (female, 32 years old) reaffirmed the importance of community-building by maintaining multiple communication channels based on her own experience running a sharing economy service: *"[In our platform] a user buys meals that someone else is cooking. We have different communication channels, one of them is a chat with a cook, Q&A... We're trying to create a cooking community and let users to create new discussions through our platform."*

5.1.4.3. Motivations

Drawing on Bellotti et al. 2015 [Bellotti et al. 2015], we clustered motivations for sharing in eight categories: (i) *self-expression and enjoyment*, (ii) *social connection*, (iii) *self-presentation, reputation and power*, (iv) *society enrichment and self-development*, (v) *altruism and empathy*, (vi) *get payment/service and convenience*, (vii) *social influence*, and (viii) *safety*.

Self-expression and enjoyment is about amusement, fun and sharing how one feels, ideas and sentiments. *Social connection* comprises communication, and creating or maintaining relationships. *Self presentation, reputation and power* is all about building an identity and impression management. *Society enrichment and self-development* is related to morality and progression. *Altruism and empathy* regards sharing to unselfishly help others. *Get payment/service and convenience* is all about instrumental purposes, to get something in return. *Social influence* involves sharing because of peer pressure, persuasion or reciprocity. *Safety* regards sharing for security purposes.

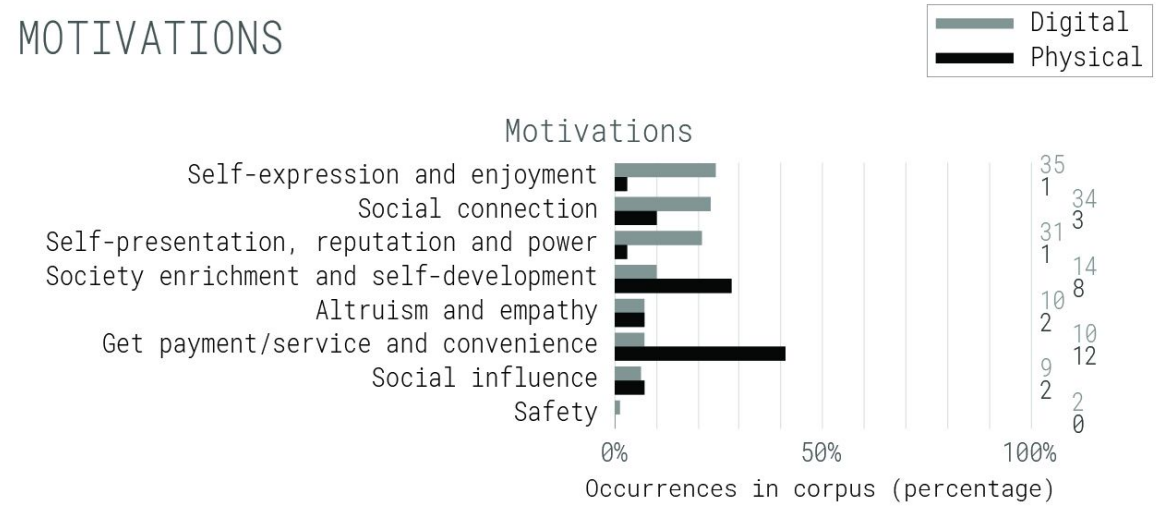


Figure 9 Motivations for sharing (digital vs. physical practices)

The content analysis suggests that the main motivations for sharing in the digital realm are *self-expression and enjoyment*, *social connection*, and *self-presentation, reputation and power*. Out of these three categories, social connection is the only one that is also evidently present in the physical realm, where we can observe that people is driven by more instrumental purposes, such as *getting a service or a payment and convenience*. Sharing physical objects is also highly motivated by *society enrichment and self-development* goals, this reason for sharing is less present in the digital environment. Lastly, *social influence* and *safety* are less determining reasons for sharing in both digital and physical realms.

The category of **self-expression and enjoyment** is surprisingly low in the physical realm. Although one can think of acts of self-expression through physical objects (e.g., displaying collections or paintings), these motivations don't seem to be present in users' sharing practices. One possible cause for this difference may be sparse prior research in understanding motivations to share personal material artifacts. However the more plausible explanation is that self-expression is something that differentiates these two realms, when people share digital content they are more interested in fulfilling self-expression [Van House et al. 2005; Goh et al. 2009; Kairam et al. 2012; Yejean Park et al. 2011; Lehtiniemi et al. 2017; Ojala et al. 2014; Litt and Hargittai 2016] and enjoyment [Mueller et al. 2010; Håkansson et al. 2007a; Lehmuskallio and Sarvas 2008; Acquisti and Gross 2006; Bayer et al. 2016; Xu et al. 2016] needs than when they share physical objects.

Some qualities of digital data, such as placelessness, spacelessness and formlessness [Odom et al. 2014], may explain why people choose digital environments to self-express. All together, these qualities enable novel forms of sharing that are hard to reproduce in the physical realm. For example one may want to share a picture from a recent trip to tell the story of how it went and share the emotions it evoked. Placelessness and formlessness allow the picture to be present at multiple locations simultaneously, it can be posted on Facebook, uploaded to Flickr and sent through email. Spacelessness allows users to create, share, and receive this content without worrying about storage issues. Formlessness and the possibility to add metadata enable the user to adjust the picture to properly fit each specific goal, the sharer can add a footnote telling how she feels about the picture before posting it on Facebook, edit it to accomplish artistic purposes on Flickr, or attach it to a whole story written in an email. Similar scenarios would be difficult to accomplish in a physical environment.

Sharing for the purpose of **social connection** is a strong motivating factor in digital sharing, but it has limited presence when it comes to sharing physical artifacts and services. Despite that, Rebecca (female, 26 years old), used ride-sharing as an example of a physical sharing practice that may create new social ties: *“There’s also the social bond that one is able to build in these practices, I believe it's a different idea, another culture of transportation, you may meet really interesting people, not the usual taxi driver.”*

The categories of (i) **self-presentation, reputation and power** and (ii) **society enrichment and self-development** present two different ways for personal and societal improvements, the first category is related to identity construction, whilst the second one is more about personal and community-development, thus making the world a better place. Sharing practices in the physical realm are motivated by society enrichment and self-development purposes [Luckner et al. 2015; Light and Briggs 2017; Bellotti et al. 2014;

Ozanne and Ballantine 2010]. On the other hand, most users sharing in the digital environment want to present themselves in favourable ways, build up a reputation or to gain power [Van House et al. 2005:20; Goh et al. 2009; Silfverberg et al. 2011; Tufekci 2008; Beldad and Citra Kusumadewi 2015; Lange 2007; Rotman and Preece 2010; Acquisti and Gross 2006].

The digital environment provides a 'safe place' for self-presentation, where users can adjust their audiences to show distinct aspects of themselves accordingly to different circles and broad audiences [Odom et al. 2011]. Virtual possessions are also easy to manipulate in order to fit specific presentation purposes and, although is hard to display them, they can be present in virtually any location [Odom et al. 2011]. Sharing in the physical realm seems to be divided into two large groups: sharing economy commercial services [Hamari et al. 2015; Ikkala and Lampinen 2014; Bardhi and Eckhardt 2012], and local communities and grassroots initiatives [Lampinen et al. 2013; Luckner et al. 2015; Taylor et al. 2016]. Although both are driven by instrumental motives, in local communities people also engage in sharing to improve the societies they live in and to gain skill or to feel better about themselves. Gladys (female, 30 years old) reflected on the importance of identity construction on more instrumental services based on her own experience using a bike sharing service: *"I want to be a user and personally I would like to participate in their organization from some other angles as well: for example to clean the bike and to protect it a bit [from being stolen]... also to say 'Look, that's a bike I use, it is my bike', not really mine but you know... I would feel much happier... somehow this aspect of community[-making] around bikes is missing there [for me]"*.

In local communities, face-to-face social interactions augment their acts of self-development when they perform good deeds. Further research is needed to understand what particular qualities of the physical environment make this motivation for sharing possible, and if those can be achieved in a digital context.

One might expect a higher value for the **altruism and empathy** category in the physical realm. It is true that a lot of people share to provide help to others, however in most cases the deeper motivation for doing it is to enrich society or to self-develop [Bellotti et al. 2014; Light and Briggs 2017], so these fall into a different category.

Lastly, motivations for sharing physical artifacts are highly instrumental, such as to earn money or to get things done. Thus, economic and practical needs are the most common reasons to engage in this type of sharing, which is usually not the case in the purely digital context, **to get paid or a service** is one of the least represented motivations for sharing in the digital environment. As described above, different features of digital content provide the users with tools for self-presentation and self-expression. There is a wide range of motivations for sharing in this realm, which lowers the amount of people that is mainly motivated by instrumental purposes (although they are still present [Van House et al. 2005; Brown et al. 2001; Mannak et al. 2004]). On the other hand, the fact that people sharing in the physical realm are motivated by society enrichment and self-development goals allows users on the other side of the exchange, receiving a service for example, to take advantage of great deals [Lampinen et al. 2013]. Worden (male, 32 years old) elaborated on reasons to engage with Airbnb from both supplier and consumer sides: *"For those hosts that are doing it full-time professionally it is clear — monetary incentives are the most important motivations, especially if they are renting an entire apartment. If they are renting a room within a place, it*

may be more about the community and experience. On the guests' side, it can be more diverse".

In addition, some acquired skills (e.g., carpentry) are not always possible to practice in a digital environment, thus some users are limited to share their help or knowledge in the physical realm [Taylor et al. 2016].

Economic and practical needs are strong motivations for engaging in physical sharing practices, this is not the case in purely digital contexts. We believe this is one of the most notable differences between digital and physical sharing practices.

5.1.4.4. Privacy and Trust

Drawing on Palen & Dourish 2003 [Palen and Dourish 2003] and Olson et al. 2005 [Olson et al. 2005], we clustered privacy and trust issues in four categories: (i) *content/identity*, (ii) *audience/disclosure*, (iii) *unconcerned*, and (iv) *trust*.

Content/Identity refers to concerns regarding to users identity and self-presentation, and intrinsic sensibility of content. *Audience/Disclosure* worries are related to sharing broadly and personal safety. *Unconcerned* people has no concerns related to privacy or trust. *Trust* is about faith in services and other people involved in the practice.

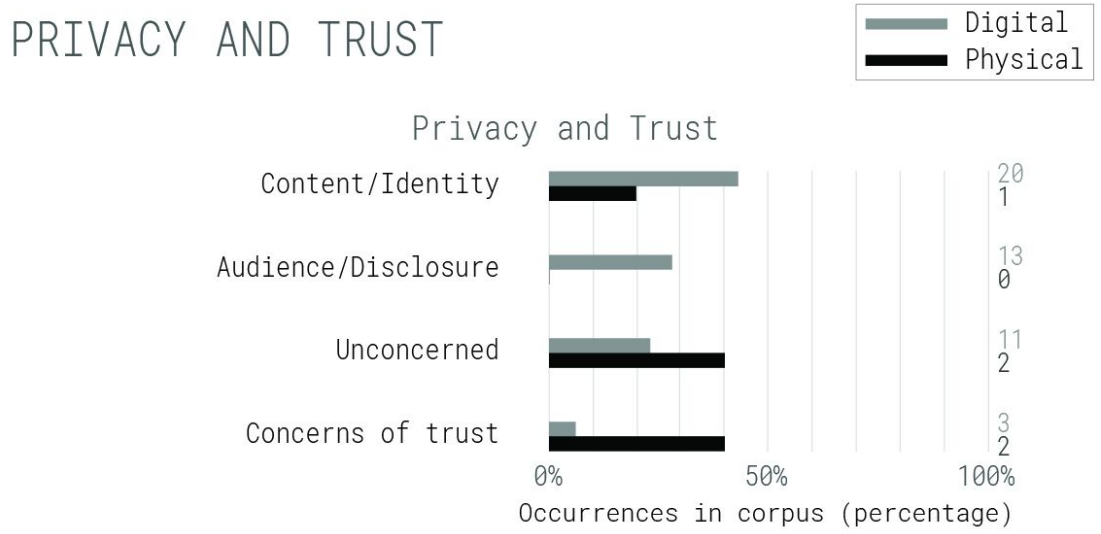


Figure 10 Privacy and trust issues while sharing (digital vs. physical practices)

The content analysis suggests that sensibility of content and identity issues are the main cause of concern in the digital realm, followed by audience and disclosure worries. In the physical realm trust issues are the most relevant, however some people have no concerns at all. There are unconcerned users in the digital environment too, although the category is less represented. The same applies for trust issues with digital content, and with content/identity concerns in the physical realm. Finally, in our sample we found no evidence of audience or disclosure issues in the physical environment.

The relevance of **content/identity** concerns in the digital realm [Acquisti and Gross 2006; Consolvo et al. 2005; Ahern et al. 2007; Voida et al. 2005; Lange 2007; Prasad et al. 2012; Silfverberg et al. 2011] may be related to self-presentation, reputation and power being main motivations for sharing. We stated that digital content makes self-presentation to multiple

audiences possible, however this does not come without concerns. It could be tough to manage one's identity online, specially because sharing in this context could mean to relinquish control over the object [Odom et al. 2012], which raises concerns about other people manipulating one's image. Human or system errors (on the side of the sharer or the service) could also have serious consequences, users might fail to manage their personal impressions if they don't take care (for example, sharing an inappropriate picture to one's boss). On top of these, the data that is shared to build a reputation or to self-present could be sensitive (such as locations, pictures and personal data), which also raises concerns and users ask themselves whether to share them at all.

Within our data corpus, people that participate in sharing economy services were not broadly concerned about these issues. In the same way, Worden (male, 32 years old) suggested that convenience weighted over his privacy concerns when he decided to sign up to Airbnb: *"My biggest concern was when I had to scan my passport for verification purposes. I wanted to be a verified user, so I would have easier time finding a place if I needed one. That's a very personal document, it was the moment when I was quite skeptical... but in the end I just signed up and hoped for the best."*

What seems to be more relevant in sharing economy services is **trust** in the recipient or the community where sharing takes place [Ikkala and Lampinen 2014; Luckner et al. 2015]. The nature of the practice demands trust. The relevant factor here is that, in a physical environment, the audience is mainly unknown people, as we have seen. Trust between exchange partners is crucial to complete a productive interaction, and that is something that strangers do not naturally have for each other. Bobby (male, 33 years old) regarded the use of reputation review systems to improve the trust within a platform and its participants: *"I believe all these tools to build and show a reputation are there to mitigate potential issues of trust. If I see 300 people stayed in this house and everyone says 'it's OK' and they are all happy with the experience, well... if nothing bad happened to them, why would it happen to me?"*

The few trust concerns we found in the digital realm are related to platform failures or external risks, which are also connected to the lack of trust in strangers.

The lack of **disclosure** issues in the physical realm may be related to the audience being mostly individuals (one-to-one), but also to the effort put into choosing exchange partners because of trust issues.

Certainly, users probably have concerns that could fall into this category before settling on an agreement, such as providing their home addresses to the general public (as similar ones are also present in the digital realm, for example when building a personal profile in a SNS). However, current services mitigate these concerns by showing this type of metadata just to trustworthy audiences. The effort put into choosing exchange partners because of trust issues is, then, combined with progressive disclosure mechanisms, which might be working as a tool to mitigate undesired audience worries in the physical realm.

Further research is needed to confirm the speculation. It could also be possible that people that are willing to share physical objects, such as houses, have no concerns revealing this type of disclosure to any audience. One way to look into it would be to ask users from a popular service (Airbnb, for instance) if they would use the platform if it didn't have mechanisms of progressive disclosure.

Furthermore, Aubrey (female, 30 years old) reflected on the privacy trade-offs that users have to make when deciding to participate in a sharing economy service: *"Considering that you can link [your profile] to the Facebook account, some people may not like it, but it is a way to make a person accountable and to be secure that you are that person... you can't be anonymous in this regard: one has to accept that the name and the age will be visible to others. You are part of the service. You have to be a part of the [online] community. It's hard to protect this kind of information in sharing economy. You're part of the transaction."*

In regard to the digital realm, difficulties with the definition of ownership and the users' concerns regarding to the sense of control over data [Odom et al. 2013] could explain why users have concerns about their data reaching undesired audiences [Munson and Consolvo 2012; Acquisti and Gross 2006; Lange 2007; Consolvo et al. 2005].

Worries exacerbate given the fact that, in a digital environment, people is able to watch anonymously, or using an alias or a fake name. Users can't be sure who they are sharing to. This may explain the difference between realms in audience/disclosure and content/identity type of concerns.

5.1.4.5. User Experience

5.1.4.5.1. Context, Interactions and Experience

Unlike in the previous themes, the three upper-level sub-themes of Context, Interactions and Experience within User Experience are less tangible in terms of data collection. Because of that, we will only reflect upon them using quotes from the interviews. However, we will provide concrete data for their lower-level themes (devices and sharing triggers) in the following subsections.

While user experience is a complex phenomenon, our participants (i) evaluated the role of positive and negative experiences with a sharing service; (ii) argued for the value of contextual feedback; and (iii) emphasized the importance of addressing users' information needs. Jehanna (female, 31 years old) illustrated that simply reading reviews of a host on a room-sharing platform could have saved her a lot of trouble: *"I created my Couchsurfing account during a trip, so I didn't look too much. I was heading to Amsterdam and I saw someone offered a place to stay, I got in touch with him and ended up staying at his place, but then I noticed he had a lot of bad reviews, I saw it at the end of my stay. My experience was not good"*. Furthermore, our participants valued effective and efficient interactions with a platform when actual sharing takes place. For instance, Worden (male, 32 years old) outlined the importance of the instant in-situ feedback feature: *"I think hotels.com, they send out these surveys immediately after you checked-in, asking how was it, how was the location— a very quick user survey. Airbnb does not provide that immediate feedback that you can give during the transaction while you are staying at the host's place, especially when he or she is physically not present [there]... like problems with electricity or noise"*. Danny (male, 31 years old), while reflecting on the Airbnb web interface, brought up the benefit of concierge-like personalized recommendations that is currently absent from commercial sharing economy services: *"The designers could leverage the available information on amenities and transportation through existing services out there: Google Maps and Yelp. Pull that and use it in a platform interface. [One can show] the most important aspects of this information and prioritize that for users, if there is a way to tailor it –*

better... like 90% of users care about transportation, 10% of users care about restaurants, can we give them that tailored experience?"

5.1.4.5.2. Devices

We clustered devices according to two different uses. The first use is to collect data, we found six types of devices to do this: (i) *mobile phones and tablets*, (ii) *wearable computers* such as smartwatches, head-mounted displays or heart-beat monitors, (iii) *personal computers*, (iv) *cameras*, (v) *office devices* like printers and scanners, and (vi) *no device*. The second use for devices is to share data, here we have six categories again: (i) *mobile phones and tablets*, (ii) *personal computers*, (iii) *portable memory devices* like USB sticks, (iv) *no device*, (v) *devices in public spaces* such as public displays, and (vi) *printed pictures*.

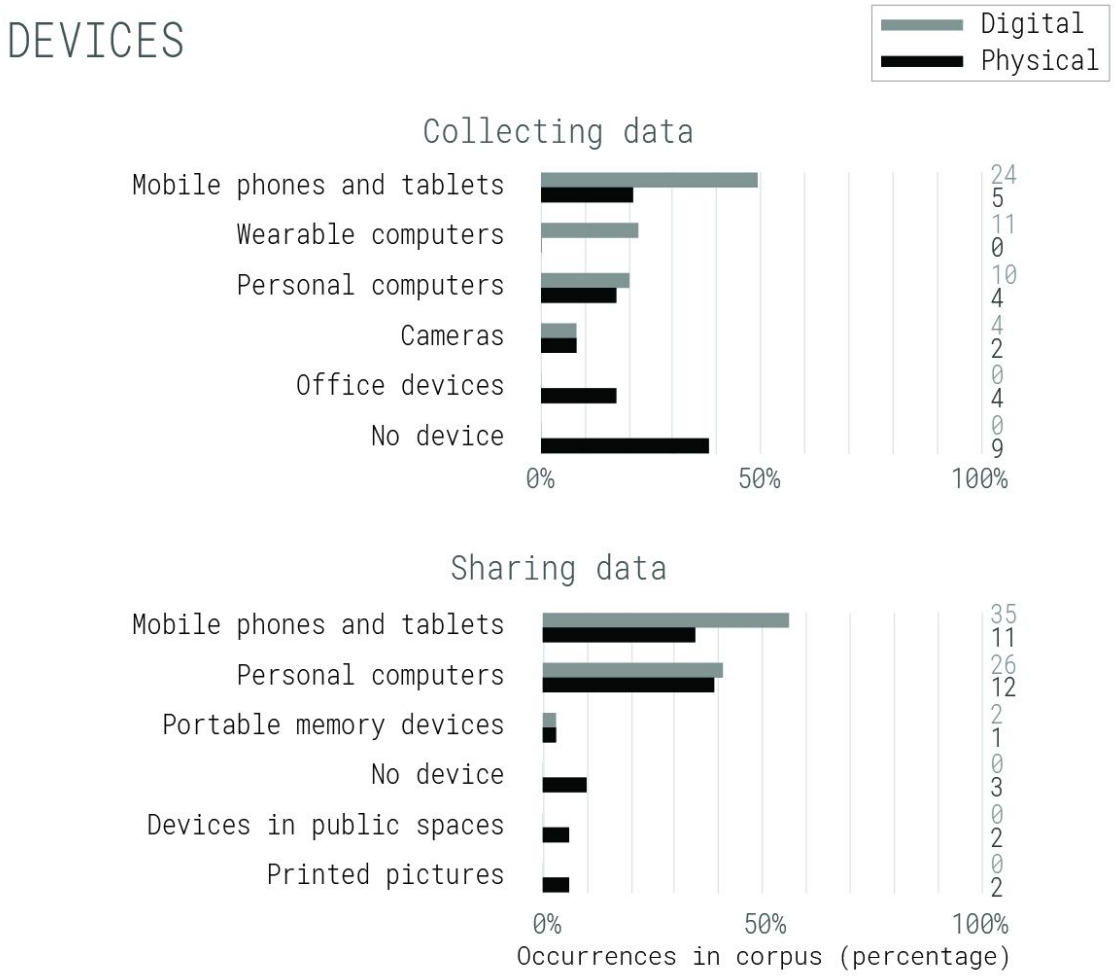


Figure 11 Devices used for sharing (digital vs. physical practices)

The content analysis suggests that the most used devices to collect data prior to sharing in the digital realm are mobile phones and tablets, followed by wearable computers and personal computers, whilst in the physical realm there is usually no need for a device to collect any data. In the cases that a device is needed, mobile phones and tablets are the most used, followed by personal computers and office devices and, lastly, cameras. Cameras are also slightly present in the digital environment. There is no evidence of office

devices being used to collect data in the digital realm, the category of no device is also null. Finally, wearable computers are not used in the physical realm.

For the purpose of sharing data, mobile phones and tablets are the most used type of device in the digital environment, followed by personal computers. In the physical realm is the other way around, personal computers are the first choice and mobile devices the second. There is also a notable amount of sharing with no device in the physical realm, other less significant, but represented, categories are devices in public spaces, printed pictures, and portable memory devices. Out of these last four categories, the only one that is slightly present in the digital realm is portable memory devices.

Digital content needs to be collected, or created, and this process requires an electronic device, however this is not the case in the physical realm, where most of the time there is **no need for a device to collect** any data [Hamari et al. 2015:201; Bellotti et al. 2015; Lampinen et al. 2013]. This is related to the fact that physical objects (such as cars, houses, or services) in this context are not 'collected' with the specific purpose of sharing them, they are rather owned prior to the desire to share. What is collected, though, is related metadata (such as plate numbers, locations, and arrangements), however it seems that previous research on the subject didn't focused on these practices. Future research might answer what type of devices are used to build announcements or to discuss arrangements.

Nevertheless, sometimes devices are needed (for example to share an account or to add information to digitally augmented objects). The fact that the category of no device is largely represented in the physical realm lowers the magnitude of the other categories, but their order of relevance reflects the same behaviour as in the digital environment, mobile devices are the most used, followed by less frequent types of devices (wearable computers in the digital environment and office devices in the physical one) and personal computers in a tie.

In the physical realm, sometimes **devices are not even needed to share** [Luckner et al. 2015; Ozanne and Ballantine 2010; Taylor et al. 2016]. Again, this lowers the numbers in the other categories but, surprisingly, in the case of sharing data the two realms do not show the same relation between the other categories. Mobile devices are also the most used to share the data in the digital environment, but the adoption of these technologies did not overcome the use of personal computers to share in the physical realm. Further research is needed to understand why this is the case. Mobile devices are usually associated with performing tasks on-the-go, does sharing a physical object require more attention? Does that explain why people is not inclined to use mobile devices in this realm, as they are in the digital one? Dacie (female, 35 years old) contemplated on the use of multiple channels when she had to book an apartment on her trip to Iceland: *"We started to communicate through the mobile [app]. However, when we were about to leave the place, we used email to agree about how to hand back the keys"*. More research is needed to properly document device preferences in diverse sharing services, specially in the physical realm, where this type of research is limited, this could help to answer the previous questions.

The analysis also shows there is a difference between devices used to collect data and those used to share. Users don't seem to share through wearable computers, office devices or cameras, which are all kinds of devices that support sharing. To our knowledge, there is no research looking to explain this behaviour. In addition, some of the latest popular devices

don’t support sharing, which we believe lessens the sharing experience, some concrete examples are Oculus, which requires for it to be connected to a computer to share content, and 360 video broadcasts, these cameras also need to be attached to a computer or mobile device to broadcast the video being captured, this is surprising because these devices are designed and advertised as social and as a modern alternative to share experiences (e.g., Facebook Spaces, whose slogan is that “VR is better with friends”). Future research may attempt to understand limitations for sharing from ‘collecting devices’ and address how to overcome them, it looks like an opportunity to improve the sharing experience to merge the two types of devices together.

5.1.4.5.3. Sharing Trigger

Building on Epstein et al. 2015 [Epstein et al. 2015], we clustered triggers in six categories: (i) *determined by the sharer*, (ii) *determined by the system*, (iii) *requested by the audience*, (iv) *streaming during a special activity or event*, (v) *led from social interactions* (e.g., sharing a photo album in a family reunion), and (vi) *always shared* (i.e., for objects shared by design, such as tools in makerspaces). We also grouped them according to two different types of sharing: (i) *manually* and (ii) *automatically* (like in some services for sharing locations or workout data).

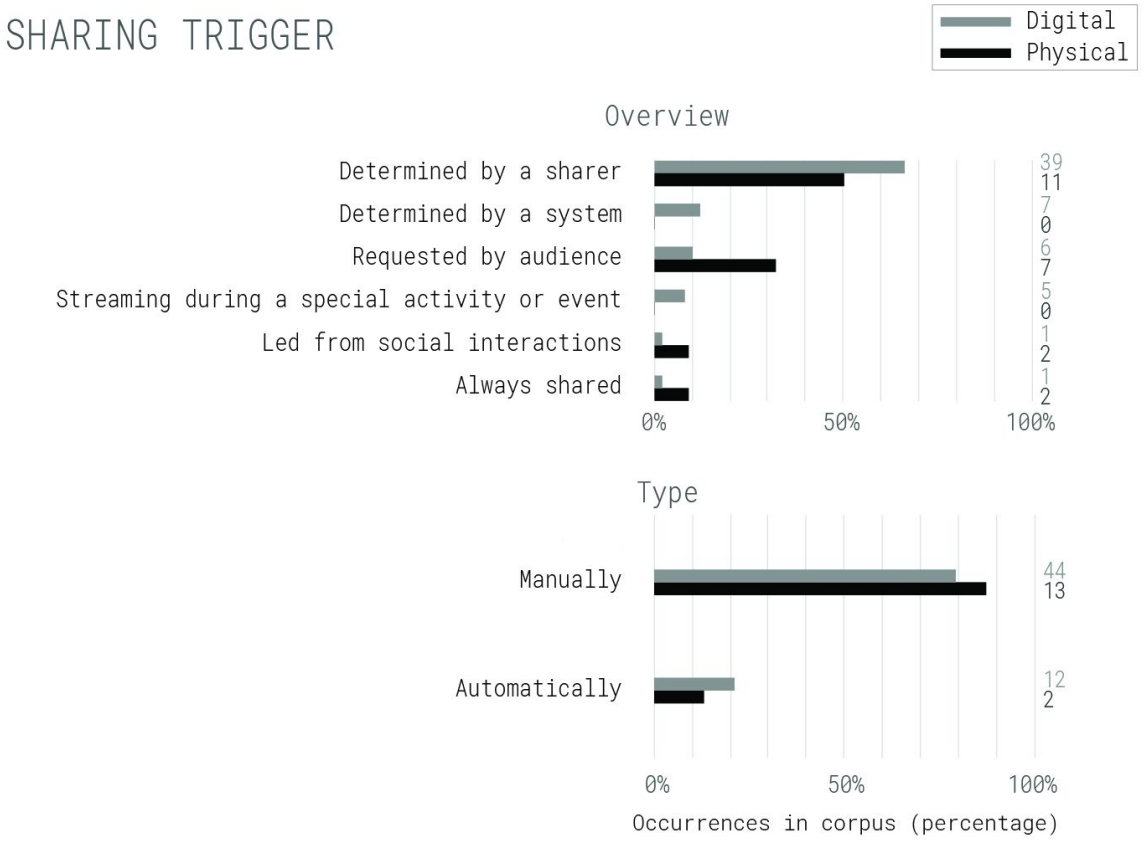


Figure 12 Sharing triggers (digital vs. physical practices)

The content analysis shows that the most frequent trigger category is *determined by the sharer*, in both realms. In the physical domain this one is followed by *determined by the audience*, which in turn is followed by the categories of *led from social interactions* and

always shared. In the case of digital content, the other categories are less present, there are some instances of sharing *determined by the system*, *requested by the audience*, and *streaming during a special activity or event*, and just one occurrence of each of the last two categories, which are *led from social interactions* and *always shared*. Finally, the categories of *determined by the system* and *streaming during a special activity or event* are not represented in the physical environment.

Regarding to the type distinction, sharing in both realms is mainly *manual* and, although there are instances of *automatic* sharing in both realms, this category is slightly more represented in the digital environment.

Users in both realms behave similarly in respect to what triggers them to share. One interesting difference is the amount of shares that happen because they are **requested by the audience**, this trigger is much more present in the physical realm [Bellotti et al. 2014; Ozanne and Ballantine 2010; Lampinen et al. 2013]. The difference may be explained by the motivations to share in each realm, some of the most important motivations in the digital environment may not need for others to share (such as self-expression and self-presentation), whilst in the physical realm instrumental goals (such as getting a service) require for users to request others to share. An alternative explanation may be that audience requests also occur in the digital realm, but these are not as successful as in the physical environment in triggering people to share, and thus are not documented by previous research. Future research might explore if any of these speculations are the case, maybe even both are accurate. If the alternative explanation is correct, then designers in the digital realm may have something to learn from those building services for the physical one. In any case, given the importance of this trigger in both realms, it should be taken into account and looks like an opportunity for improvement, especially knowing that previous research states that people may not like to ask for help in this context [Bellotti et al. 2014; Lampinen et al. 2013].

We found no instances of '**determined by the system**' triggers in the physical realm. We believe it is worth to explore these mechanisms in the physical environment. Example use cases could range from automatically accepting to provide help to the people who require it, only in case the user's skills are inline with the request (providing the service with some rules beforehand), to instantly sharing a key (or a door code) or the WiFi password after paying for a reservation through Airbnb. An example of an actual feature following this path is Airbnb's 'instant booking' option. If a host enables this option for a space, guests who meet some requirements will be able to automatically book it. As mentioned above, similar features could be useful in service-sharing platforms (such as timebanks), and could also be further developed in sharing economy services, as in the previous Airbnb example, to achieve more convenient exchanges.

Researchers may also explore more subtle alternative ways to leverage this finding, for example Morten (male, 33 years old) suggested to consider some elements of automation in sharing economy platforms in the following way: *"One nice option would be, for example, when I am renting an apartment abroad, [the platform] could make me a reciprocal offer: 'Why would not you rent your apartment when you are away?' This [approach] can be used as an enrolling process for new hosts."*

Automatic triggers are common in digital sharing. For example, workout tracking apps can determine the exact time when a user finished her run and share detailed statistics immediately after. Usually, sharing triggers in physical sharing are driven manually by the user. Nevertheless, it seems reasonable to consider some elements of automation in sharing economy platforms. Blanca (female, 30 years old) explained the nature of the request mechanism in Airbnb and outlined potential challenges related to reliability and authenticity that can be associated with immediate responses: *"If you are the person who is looking for a flat, a host needs to approve your request... there are some hints [in the interface of a platform] like 'this person normally answers within a range of 6 hours'... or even 'instantly'. However, this does not tell you if this 'person' is just a bot or not"*. Further research is needed to study how users would receive these features.

5.1.5. Design considerations

The previous findings help to illustrate commonalities and differences of sharing of digital and physical artifacts. As a brief summary, we list five key differences between these two practices:

1. The shared content: sharing physical artifacts often encompasses not only the shared material object itself, but also the accompanying layers of metadata; in digital sharing, content is exclusively immaterial.

2. The recipients of a shared artifact: unknown audiences in physical sharing vs. family members and friends in digital sharing.

3. The motivations for sharing: physical sharing is often driven by economic and practical needs (e.g., getting monetary benefits), while digital sharing is largely guided by self-expression.

4. The substantial concerns of trust in physical vs digital sharing.

5. The sharing triggers: in physical sharing, a borrower/renter proactively needs to express an interest in a shared artifact, while sharing digital artifacts is often initiated by a sharer.

In what immediately follows, we discuss the implications for design that these key findings offer for contemporary and future sharing economy services.

Worden and many of our other participants indicated the dual nature of content when sharing physical artifacts. Besides sharing "a thing" itself (e.g., car), there is a supporting layer of digital information that is shared along with it. This included both machine-produced forms of information and metadata captured by virtue or use of a platform's digital infrastructure, and human-produced digital records through directly taking and uploading the information (e.g., photos of a car, textual annotations). This information often affords opportunities to build a narrative around the artifact itself. Leveraging nascent research in HCI that aims to bridge the gap between physical artifacts and their digital representations through collecting metadata [Odom et al. 2011], provenance [de Jode et al. 2012] and histories of use [Benford et al. 2016], we see the value for designers to use these strategies

to communicate information about the ownership, duration of a share, provide contextual suggestions of use of an artifact, and preserve and share previous interactions with it. This not only can improve the overall user experience with the shared artifact itself, but also can afford opportunities for social interactions around it [Fedosov et al. 2018].

Our findings suggest that physical sharing is largely carried out with unknown people [Ikkala and Lampinen 2014; Lampinen 2014; Ozanne and Ballantine 2010]. It can be partially explained by the advent of the sharing economy services, where people participate in an exchange for monetary compensation [Bellotti et al. 2015]. To effectively advertise and execute the sharing transaction, sufficient level of details must be provided about the shared artifact or service. Designers of sharing economy platforms should provide appropriate levels of controls for the user to help balance an adequate level of disclosure of personal information and the details of a shared artifact. Modern sharing economy platforms incorporate progressive disclosure mechanisms [Fedosov et al. 2018] that reveal adequate amounts of content at a given stage in the transaction. In addition to that, service designers may want to consider concealing information upon the completion of a transaction, due to some possible negative consequences (as in the case of our participant Danny, who was accused of smoking after having already departed from a rented property). One interesting option in this respect may be smart-contracting technologies [Elsden et al. 2018], which can automatically enforce a "departure contract" by simply retrieving data from installed sensors at home (e.g., smoke detectors). While such technologies may offer straightforward evidence and minimize ambiguities when it comes to the issues of liability in sharing economy, the extent of their deployment and enforcement should take the larger social organization of the service into consideration, since it can influence social relationships among peers and the community at large. Finally, in contrast to digital sharing, where shared content can scale to reach multiple audiences at the same time [Odom et al. 2014; Vitak 2012], physical sharing limits people share to one individual (or small group) at a time, which may delay decision-making as in the case of Dacie. We suggest that designers of future physical sharing services explore viable user interface techniques (e.g., access control mechanisms) where the shared artifact (and their digital counterparts) can be ultimately accessed and maintained by a group of involved stakeholders.

When it comes to motivations to share, we want to get back to our framing of two different logics of sharing. We found that prior research in HCI has paid a lot of attention to digital sharing as an act of *communication*, while only few works explored this logic in the context of physical sharing practices [Bentley et al. 2006; Frohlich et al. 2002; Miller and Edwards 2007; Nunes et al. 2008]. Researchers explained that participation in online sharing stems from people's desires to create and maintain social ties [Goh et al. 2009; Lange 2007; Rotman and Preece 2010], needs for self-expression [Goh et al. 2009; Van House et al. 2005; Kairam et al. 2012; Yejean Park et al. 2011] and generally from the hedonic qualities of sharing experiences online [Acquisti and Gross 2006; Bayer et al. 2016; Lee et al. 2015; Miller and Edwards 2007; Xu et al. 2016]. However, these social phenomena were less accentuated in prior research in physical sharing. This may indicate an opportunity for research to explore communicative aspects of physical sharing. In practice, designers of sharing economy services can explicitly emphasize the advantages of maintaining social

relationships, for example through illustrating the benefits of reciprocity. As our participant Morten proposed, this can facilitate enrolling new users in a sharing economy platform.

Our findings identified that the main concerns of sharing physical artifacts are rooted in the lack of trust in a counterpart of the sharing transaction [Ikkala and Lampinen 2014; Luckner et al. 2015]. Sharing economy services (which account for most of physical sharing in our data corpus) are carried out broadly with unknown individuals, and trust is something that strangers do not naturally have for each other. Therefore, we have emphasized that it is of crucial importance for designers of physical sharing services to provide mechanisms and tools to build trust between potential exchange partners. Furthermore, we speculate that presenting accounts of successful exchanges may contribute to the overall endurance and growth of the sharing platforms and communities over time. Some commercial sharing economy services have already adapted various mechanisms to build trust within the community and the platform through reputation review systems, transparent profiling, and offline-identification for the providers of the shared resources. It follows that, in order to build attractive and trustworthy social profiles within platforms, designers need to explain the benefits and provide tools to de-anonymize participants within a sharing platform, as aliases, nicknames, or incomplete profiles are not considered trustworthy to engage in community building [Bardhi and Eckhardt 2012]. Note that while more disclosures are encouraged, owing to the fact that self-descriptive profiles can contribute to making informed decisions [Ert et al. 2016] and are perceived more trustworthy [Ma et al. 2017], there may be some negative consequences designers should be aware of, such as “digital” discrimination based on the aspects of appearance (e.g., race, gender [Edelman and Luca 2014]).

During our analysis, we have encountered a difference between the triggers to share in physical and digital sharing. When sharing physical artifacts the number of shares that happen by request from the audience is much more represented than whilst sharing digital artifacts [Bellotti et al. 2014; Lampinen et al. 2013; Ozanne and Ballantine 2010]. The difference may be explained by the motivations to share. While digital sharing is driven by self-expression and self-representation, in physical sharing motivations are largely instrumental and driven by inquires to borrow an object or provide a service based on the demand of the audience. Designers of future physical sharing platforms may proactively explore the needs of the audience to leverage these behaviors.

Note that the pro-social rhetoric of sharing (e.g., openness, trust, commonality and understanding between people) [John 2017] are rarely placed at the center of attention in popular profit-driven sharing economy services. Nevertheless, we envision that the wider adoption of platform cooperatives [Scholz 2016], with their commitments to cultural and community values over economic gain, can empower service designers to develop and evaluate sharing triggers that follow from social interactions. Ultimately, in our data we found no instances of sharing ‘determined by the system’ in physical sharing. However, examples of such practices exist (e.g. Airbnb’s ‘instant booking’ feature, which allows guests who meet predefined requirements to automatically book a space without an additional host’s approval). Sharing economy services could take a step further in this direction and enable to, for example, instantly share a WiFi password, provide an access code for a building, or even open a door or locker using some IoT-based technology (e.g. Slock.it) after a user confirms a reservation. Designers of physical sharing services could explore the opportunities to

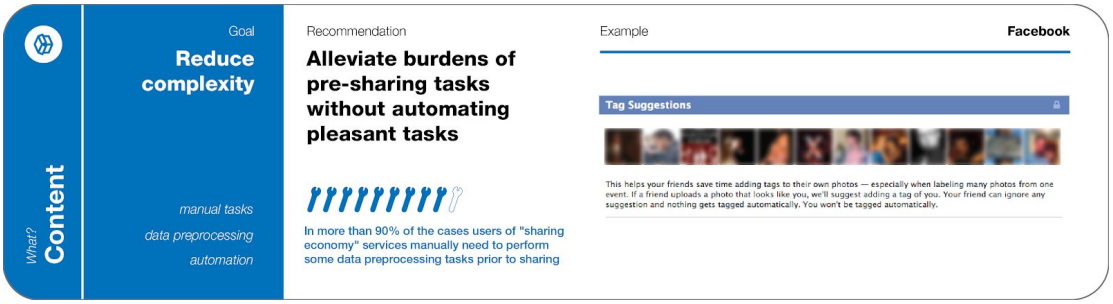
include automatic sharing capabilities, based on user needs and available infrastructure. For example, community owned lending libraries of things (e.g., thethingery.com) may benefit from the computerized pick-up/drop-off stations (similarly to the self-service parcel lockers used by a number of European postal services) for their members to facilitate exchanges of tools and equipment, and to assist in emergency preparedness in neighborhoods.

In addition to these key thoughts, we also provide a complete set of 24 design considerations based on these and other of the aforementioned findings, together with our reflections upon them, considering relationships with previous research in interaction design that looks into bridging personal physical and virtual artifacts.

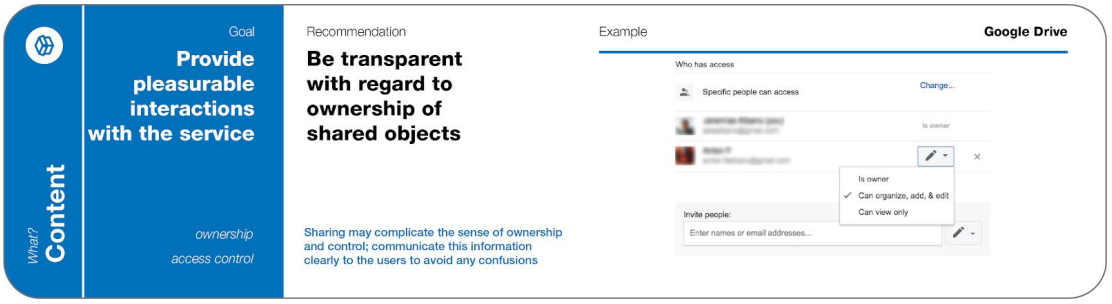
We present each design considerations in two formats: (1) as plain text for the reader of this document, where we also introduce it with a succinct recap of the finding that motivated the suggestion, and (2) as *cards* for potential designers of sharing services. The design cards could be used not only to create new physical sharing services but also to evaluate or extend the existing ones. Based on recent work of Colusso et al. [Colusso et al. 2017] we tailored cards for service design practitioners by providing actionable recommendations, genuine examples and simplifying search efforts through the use of keywords.

The design considerations are the following:

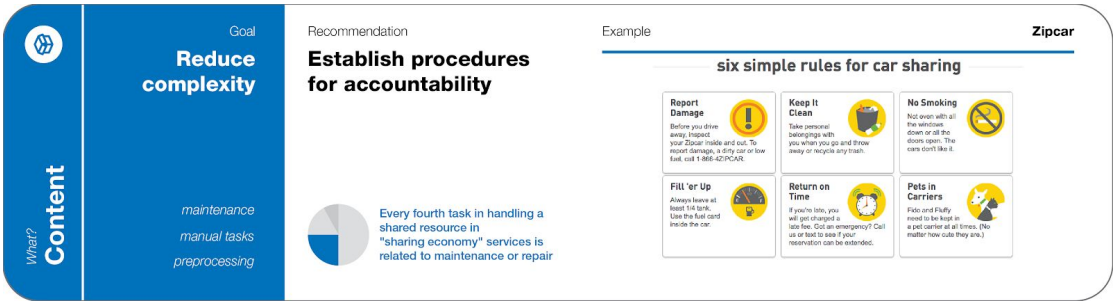
1. There are no instances of automatic preprocessing in sharing physical real-world items, most users carry out a number of manual tasks (e.g., labeling, cleaning, compiling instruction sets) before sharing. However, people might enjoy performing some of these tasks. Services should *relieve burdens of pre-sharing tasks, without automating pleasant tasks*.



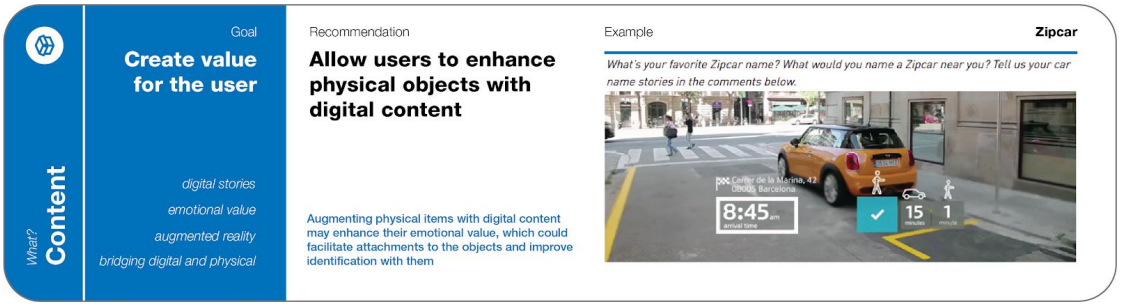
2. Changes of ownership are a common practice in physical item sharing. We have learned from the digital realm that sharing may complicate the sense of ownership and control, and that this, in turn, could aggravate privacy concerns and issues (worries regarding to data reaching undesired audiences, for instance). We recommend services to *be transparent with regard to ownership of shared objects*.



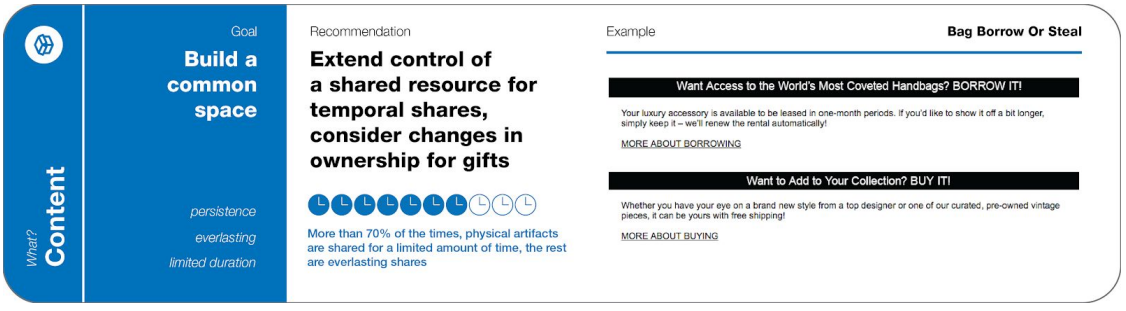
3. Due to their material nature, physical objects require maintenance and repair. Those tasks may drive people away from the service, however taking the responsibility on the side of the service may entail infrastructural and organizational changes (more employees, etc). Services should *consider pros and cons of making the users responsible for maintenance and repair*.



4. Similarly to digital artifacts, metadata of physical objects could be a valuable resource for tracking provenance and histories of use. Augmenting physical items with digital content may enhance their emotional value. This could facilitate attachments to the objects and improve identification with them, users' may feel represented by the shared object. In turn, this may diminish opportunistic behaviors (e.g., not cleaning the car before returning it). Service designers could *consider allowing users to enhance physical objects with digital content*.

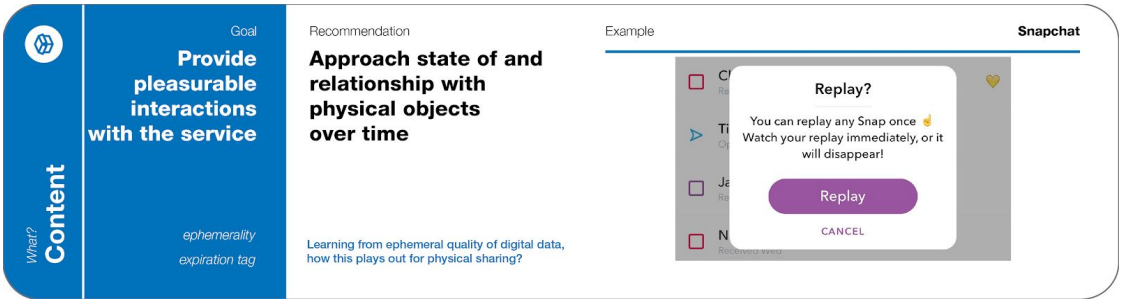


5. Most sharing practices in the physical realm are limited in duration, in other words they extend control of the object to another individual or group (e.g., borrowing a car). However there is an increasing amount of instances where users share everlastingly, that is changes in ownership (e.g., gift-giving). We suggest designers to *focus on sharing practices of limited duration when it comes to sharing real-world artifacts, and extensions of control over content, without compromising practices of everlasting nature*.

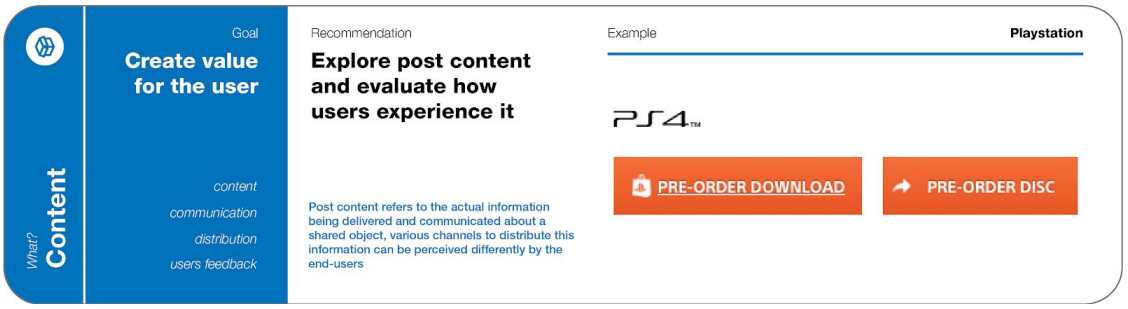


6. Ephemerality is naturally embedded in some aspects of physical objects, (the time of access, their pristine condition and even the relationships around sharing them can

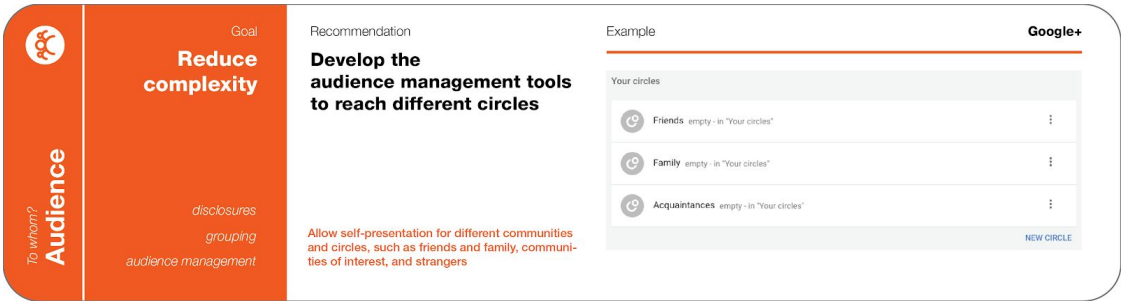
be impermanent). Some sharing services in the digital realm successfully leverage this quality (e.g., Snapchat). Service designers should *approach ephemeral characteristics of physical objects as features, not as hindrances*.



7. Different forms of 'post content' (i.e., the actual form in which information is being shared, may be physical objects, virtual possessions, etc.) could trigger diverse responses from the users. This dimension has not been extensively explored by researchers, it seems there is a lot of room to develop creative ideas. Service designers should *explore different forms of 'post content' and study how users experience them*.

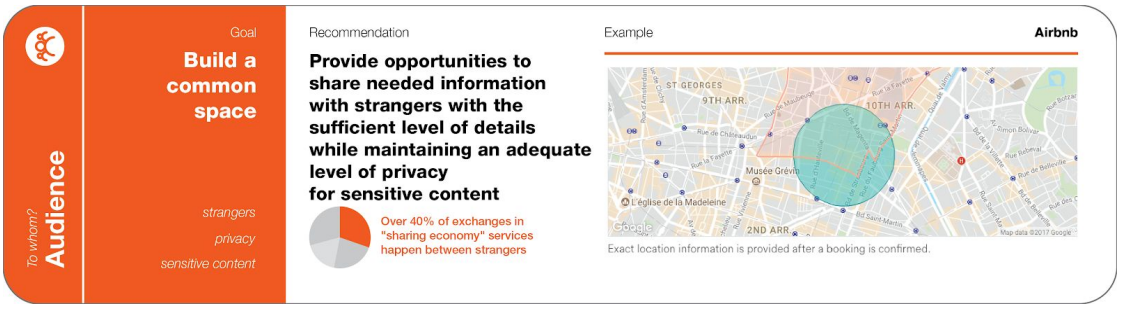


8. From the sharing on social networks we have learned that context collapse introduces a number of challenges related to self-representation to various audiences, and that we should try to avoid it through easy-to-use tools with minimalistic interfaces. The content analysis shows that, in the physical realm, audiences are mostly composed of individuals from three categories, thus three pre-defined audience circles could be enough for most users. Services could *enable simple tools for creating and selecting circles, distinguishing between (i) friends and family, (ii) interest communities, and (iii) strangers*.

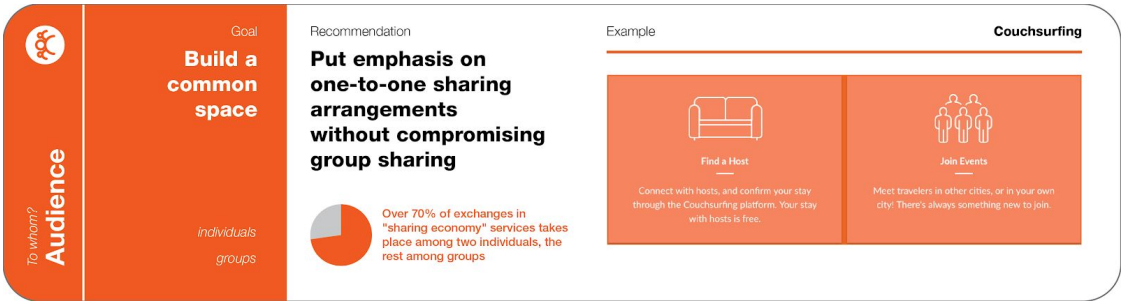


9. Audiences within sharing economy and physical item-sharing services are mainly composed of unknown people. Services should *make it possible to share necessary information with strangers with sufficient level of details while maintaining an*

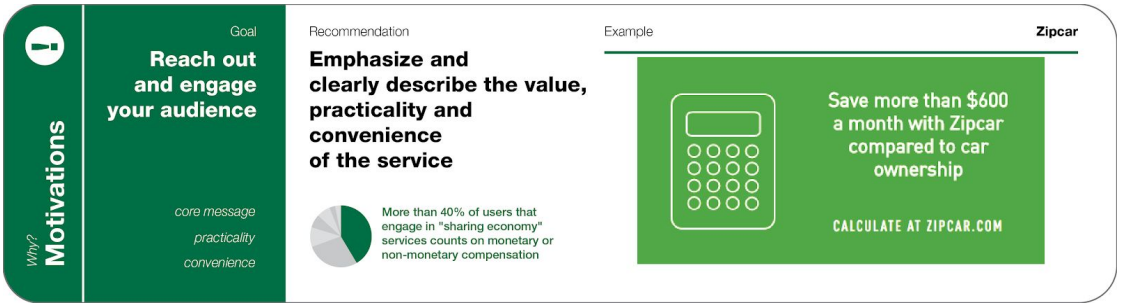
adequate level of privacy for sensitive content.



10. Most of the time people share to one individual at a time, although there are instances of physical sharing with more than one receiver. Services could *put emphasis to exercise one-to-one sharing practices, without compromising group sharing*.



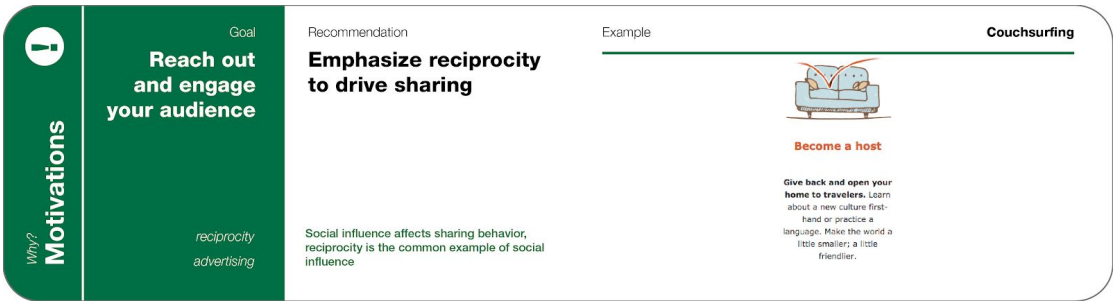
11. Sharing in the physical realm is largely motivated by instrumental needs, such as getting a service or a payment, and increasing convenience. Designers should *emphasize and clearly describe value*, *practicality and convenience of the service*.



12. People also share to self-develop (to become a better person) and to enrich society (to make the world a better place). We suggest designers to *describe the opportunities that lead to self-development and society enrichment* within a service.

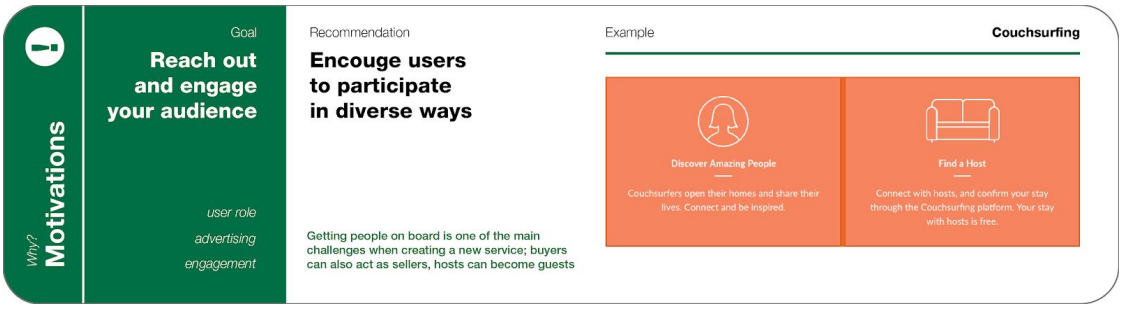
13. Sharing creates and regulates social ties, both as a communicative (e.g., sharing feelings) and as a distributive practice (e.g., sharing a candy bar), many modern SNS use the word 'share' when they encourage their users to 'socialize' [John 2013b]. Sharing for the purpose of creating and maintaining a social connection is a common practice in both realms. Services should *support creating and maintaining social relationships*.

14. Social influence is a motivational aspect that similarly facilitates in both realms. Reciprocity is one of the most common practices in relation to this motivation, especially in the digital realm where it is a main motivation for sharing in several domains (such as music, files and biometrical data sharing). We believe designers of physical item-sharing and sharing economy services could *use reciprocity as a way to drive sharing, encouraging users to share due to reciprocity*.

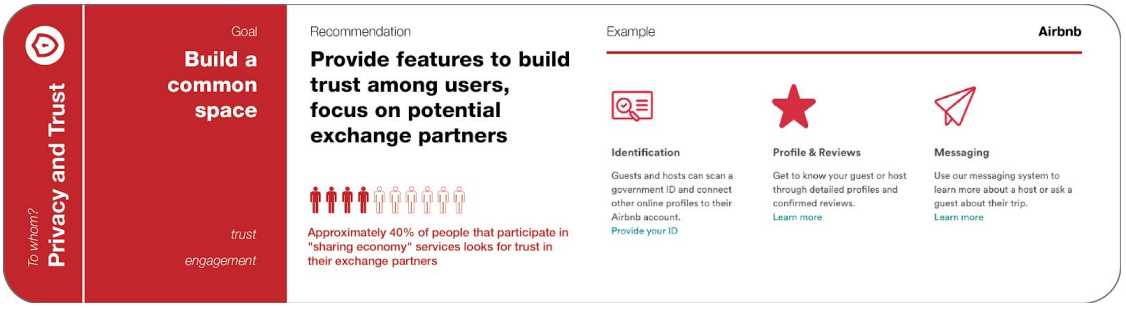


15. Previous research states that getting enough participants to create a steady flow of transactions (what is called “thickness”) is one of the main challenges when building a sharing service, one way to tackle the issue is to *encourage participants to engage in diverse ways* (buyers can also act as sellers, hosts can become guests) [Lampinen and Brown 2017]. The content analysis shows that there are several factors that motivate people to share in the physical realm, one way to encourage users to participate in new ways may be to invite them to explore their other opportunities (e.g., make them notice their possibilities for self-development and society-enrichment in case they use the platform just because of practical need). Another opportunity for improvement is to increase fun and enjoyment of the service,

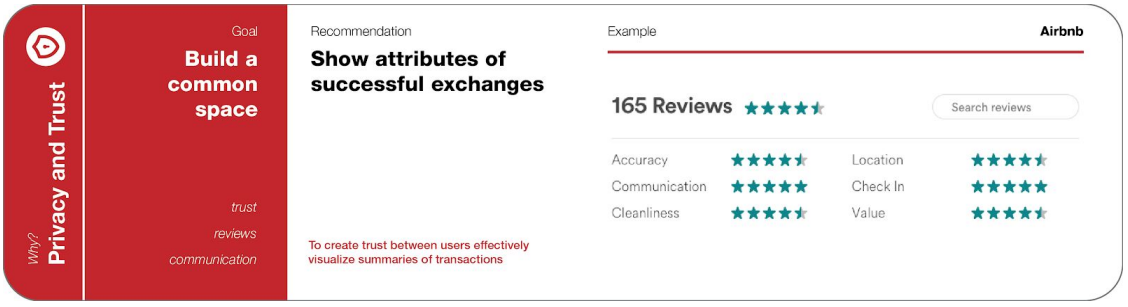
which we have seen is currently lacking in the physical realm.



16. Users of sharing economy services are usually strangers to each other. Thus, trust between exchange partners is crucial in sharing physical artifacts. Sharing services should *provide features to build trust between users, with focus on potential exchange partners*.

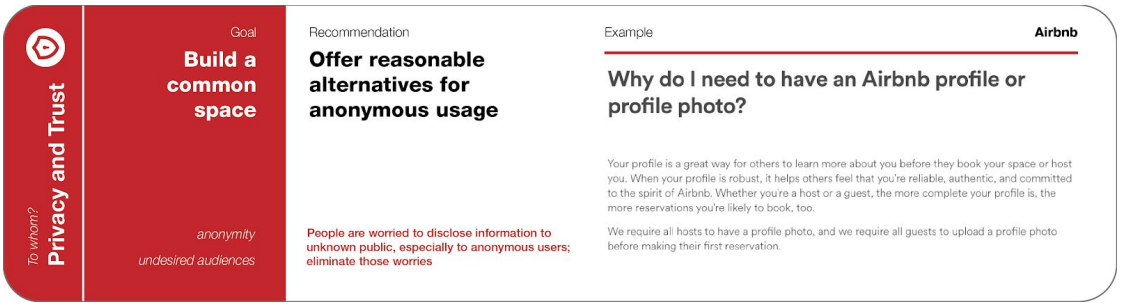


17. Previous work states that another way to improve “thickness” is to *show signs of successful exchanges*, arguing that it is important for the growth of the community to effectively communicate outcomes [Lampinen and Brown 2017; Taylor et al. 2016]. This could also help to build trust in the service and its community, which the content analysis suggests it is a major issue in the physical realm.

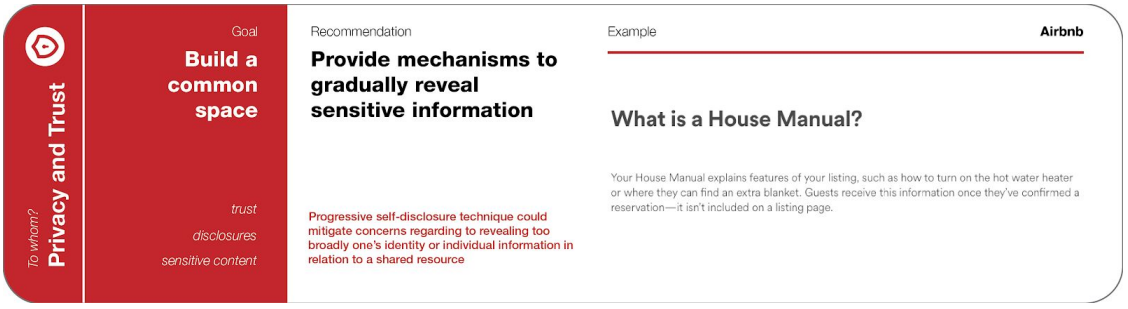


18. The most common privacy concerns in the digital realm (i.e., sensitive content, identity related difficulties and problems with undesired audiences) aggravate due to the fact that people can follow anonymously, users can't be sure who they are sharing to. We see this behavior to happen in sharing economy services and platforms, thus we advise designers to *decrease the possibilities for anonymity, or provide reasonable alternatives* (e.g., providing little personal information, such as

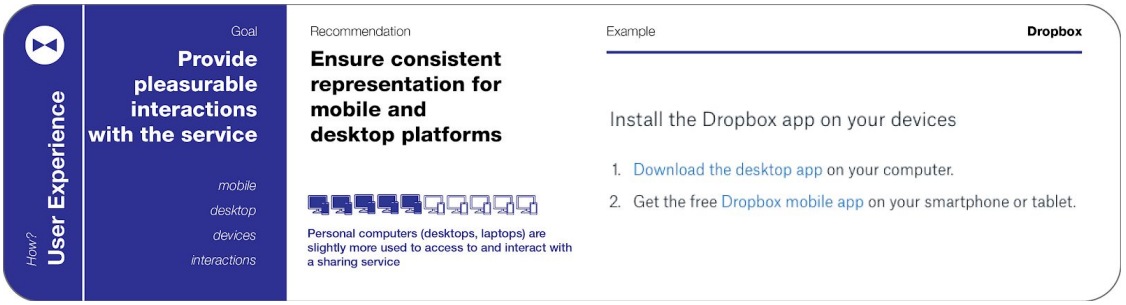
name, age and city).



19. A number of features of current sharing economy services may be helping to mitigate privacy concerns related to undesired audiences (such as Airbnb revealing the host's exact address only after a booking). These tools enable showing sensitive data only to trustworthy audiences. We advise designers to *provide mechanisms for progressive disclosure*.

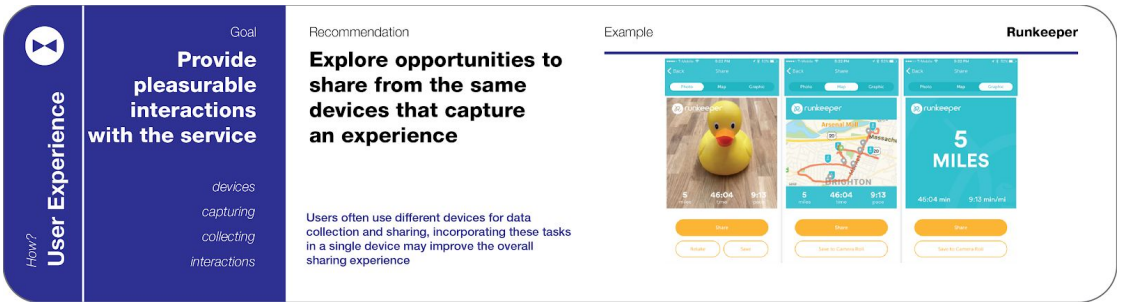


20. Personal computers are slightly more used to annotate, advertise and share physical objects than mobile devices. Hence 'mobiles first' design may not necessarily be a first choice when it comes to services that provide sharing real-world artifacts. Service designers should *consider designing for personal computers as important as designing for mobile devices*.

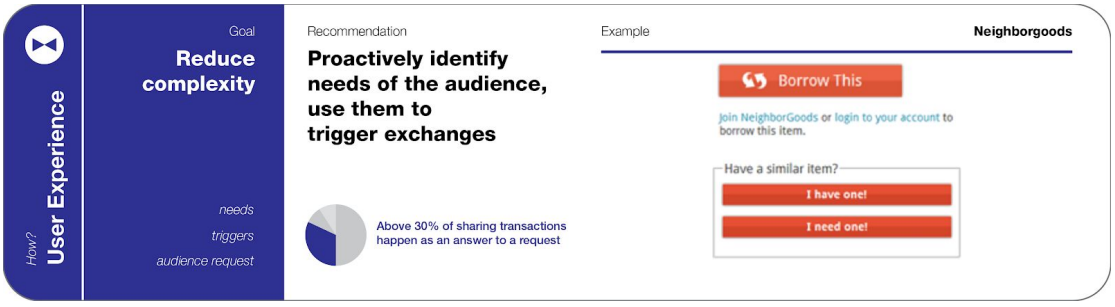


21. User's don't share through the same devices they use to collect data about a shared artifact. In addition to multi-device use strategies, service designers may *evaluate opportunities and provide affordances to enable data collection and sharing from a*

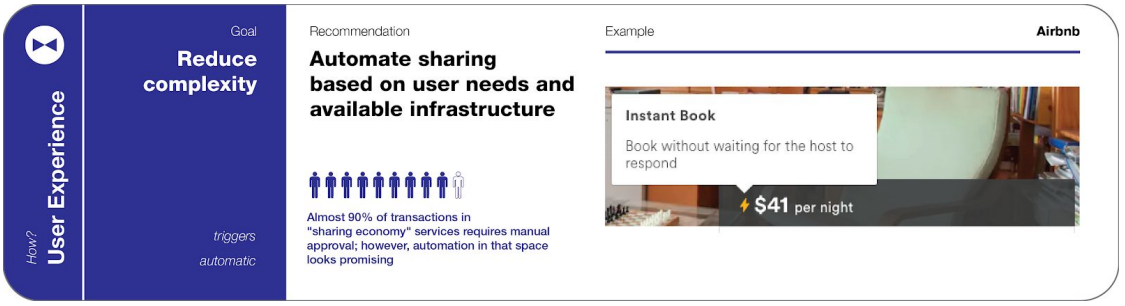
single device.



22. Besides the fact that people might not like to ask for help, sharing as an answer to a request is a common practice in the physical realm, for services (e.g., assisting a neighbor who asked for help moving) and items as well (e.g., answering to other's wishlist on Neighborgoods). Designers could *exploit needs of the audience as triggers for sharing, and encourage asking for help, requesting a service, etc*.

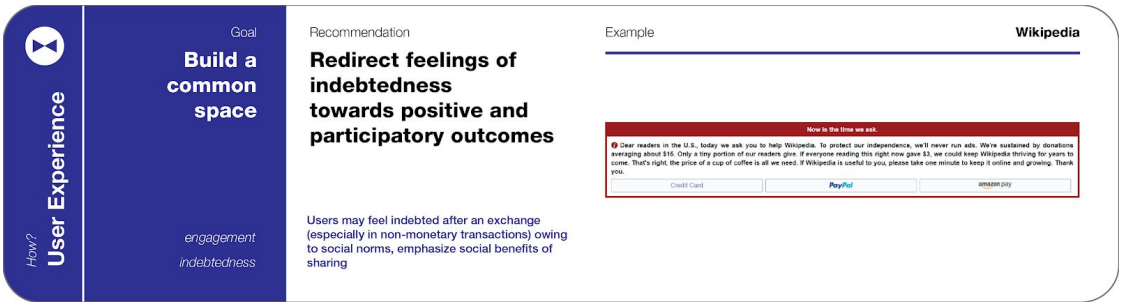


23. There are not many cases of automatic forms of sharing in the physical realm, however the few known instances (makerspaces, car sharing, etc.) seem to have good results. Examining the possibilities for the system to automatically determine instances of sharing seems promising, we believe it is worth to explore these mechanisms in the physical environment (e.g. Airbnb's 'instant booking' feature, employing smart contracting for IoT-enabled sharing). Designers could *explore opportunities to share automatically based on user needs and available infrastructure*.



24. The content analysis shows that social connections are one of the users considerations in regard to sharing, and that social norms also influence people. However, these do not always act as drivers for sharing, previous work shows that users may feel dissatisfaction or even being indebted at the completion of an exchange [Lampinen et al. 2013]. Designers should *redirect feelings of indebtedness towards positive and participatory outcomes*, such as engaging on an exchange to help a third party, which may alleviate feelings of indebtedness and create more

interactions with the service at the same time [Lampinen et al. 2013].



The set of design consideration cards can also be found at an annex of this document, in a more suitable image quality for improved readability.

5.1.6. End-user experiment

In this section we present the results of an evaluation designed to understand the certainty of the design considerations we arrived at, which also pretends to serve as an example on how to leverage the recommendations in actual design activities for online sharing services. We limited the scope of our analysis to two design considerations: number 9 and number 17. The first one talks about maintaining an adequate level of privacy for sensitive content, and the second one advises to show attributes of successful exchanges. Both will be discussed more in depth shortly.

For this purpose, we asked 20 participants (3 were later discarded because of bad data quality) to navigate through a set of fictional online sharing services in order to explore their decision making processes in relation to the context of each design consideration. We tracked their interface selections, mouse clicks, mouse movement and, more importantly, their eye movements using eye-tracking hardware.

The experiment consisted in three tests, each one with twelve different trials. The first test explores design consideration number 9 (*DC9 Test*), the second one puts design consideration number 17 to the test (*DC17 Test*) and the third one acts as a distraction to introduce some variation to the task (to avoid too much repetition and keep and monitor a high level of arousal) and serves eye-tracking calibration purposes, this last one has two different variants (*Trail Making Test A* and *Trail Making Test B*). The Trail Making Test [Reitan 1955] is a neuropsychological test used in clinics to assess cognitive functions, in particular executive functions.

We split this section into two parts. First, we will describe each one of the experiment's tests in depth, and then, we will provide our observations of the gathered data and final conclusions.

5.1.6.1. Experiment description

Participants were presented with 12 trials for each test, trials were sorted at random whilst the displaying of tests had a specific fixed order. Figure 13 describes the complete experiment workflow for a given participant.

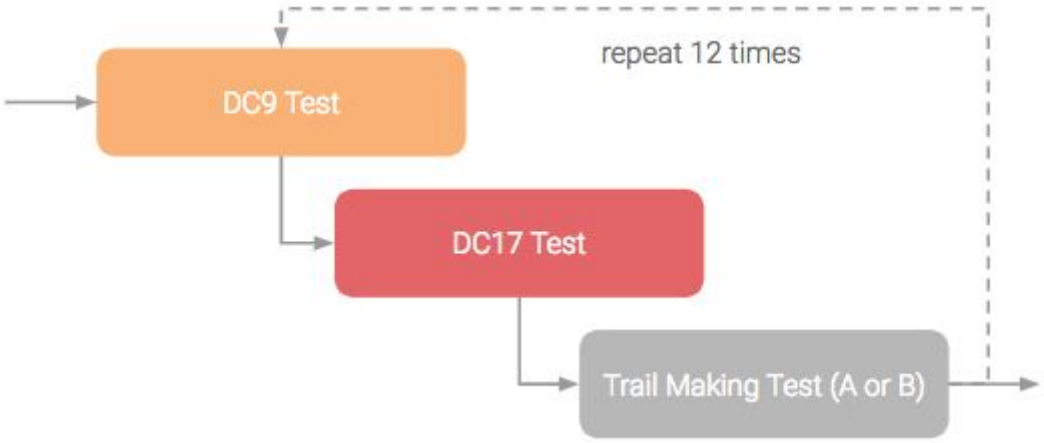


Figure 13 End-user experiment workflow

5.1.6.1.1. DC9 Test

The purpose of this test was to evaluate and put to the practice design consideration number 9.

This design consideration is related to audience management and progressive disclosure mechanisms. The recommendation is to pay attention to what kind of data a service shares (and how it does it) in order to accomplish a successful exchange between two complete strangers.

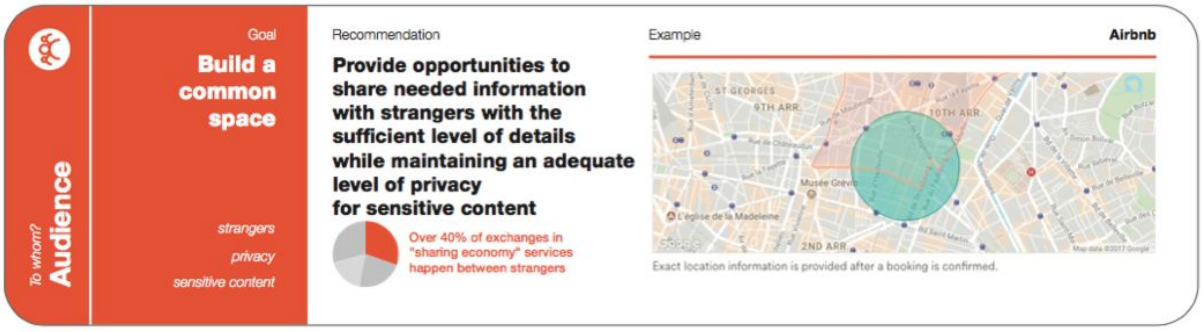


Figure 14 Design consideration number 9

A service shouldn't ask their users to share unnecessary data if it would make them uncomfortable. Our goal here is to:

- confirm that users pay attention to their privacy and revealing to undesired audiences,
- understand with what types of personal data the users feel uncomfortable sharing, and
- explore if offering diverse granularity levels for sensitive data alleviates privacy concerns.

For this purpose, we designed a fictional online sharing platform and asked participants to impersonate users of the service under several circumstances. Specifically, participants were prompted with different scenarios in which they had to set up their public profiles, which they needed to complete in order to borrow an item from their neighbors. An example of a trial is shown in figure 15 (in spanish, the participants' language).

Figure 15 DC9 Test trial example

The configurable fields where nickname, age, ID, profile picture, location address and motive of the request. Each one was filled with a few alternatives to select from. In order to force participants into potentially uncomfortable scenarios, we randomized default settings and disabled various options in some trials.

Our plan was to measure how much time do participants take to set up each piece of information, tracking mouse and eye movements to follow the attention focus and measuring how much time participants spent on each region, we read longer times as indicators of a need to pay more attention to the item. In other words, we translate time spent into concern levels for each field. Gaze time is a good indicator for this purpose.

We also asked participants to complete a 5-points Likert-scale conformity survey after each trial to understand if they were comfortable with their submissions. This is particularly useful for trials where participants had limited options to choose from. This survey is shown in figure 16 (in spanish).

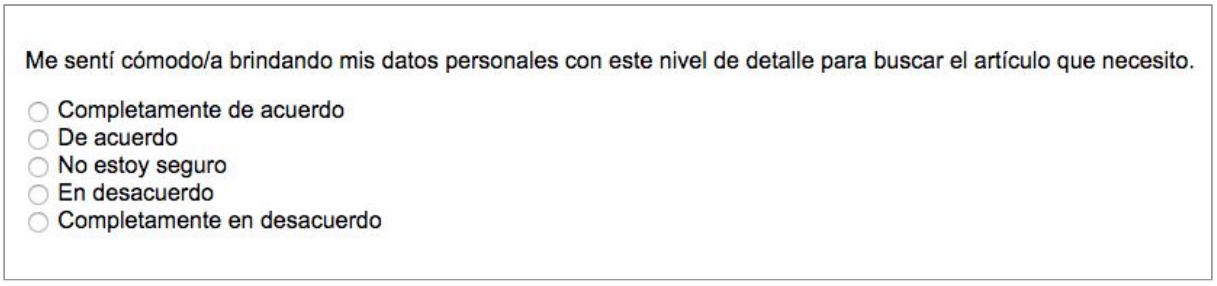


Figure 16 Compliance survey for DC9 Test

To better understand what kind of observations we presumed to elaborate upon, we state some of our hypotheses. We expected participants to:

- take more time choosing their picture and location settings than selecting options for the other fields,
- be comfortable posting profiles were no restrictions were applied to the fields, and be uncomfortable sharing profiles when we limit their ability to hide sensitive data.

5.1.6.1.2. DC17 Test

This test explored the applicability of design consideration number 17.

The recommendation is to exploit past successful exchanges in order to relieve potential privacy and trust concerns of newer users.

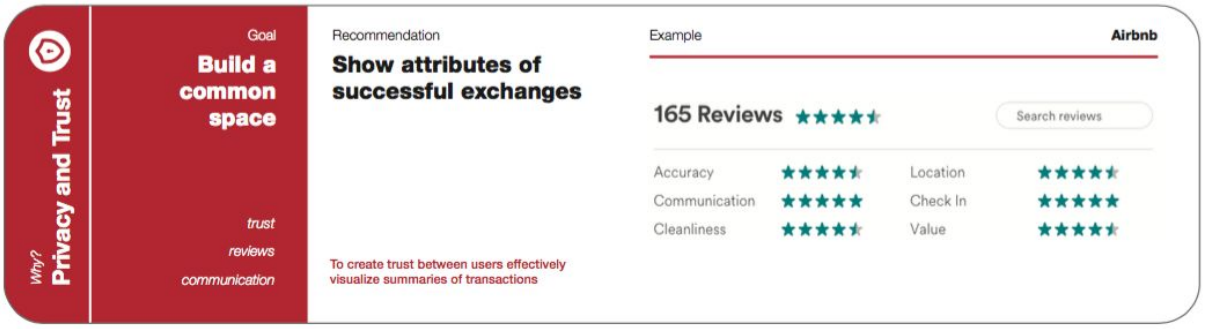


Figure 17 Design consideration number 17

One of the most common features of online services that might be following this consideration is the reviews tool. Usually these mechanisms present in one of two shapes: comments of other users or ratings (sometimes aggregated, and regularly in the form of a 1-to-10 score or 1-to-5 stars scale). Having this in mind, we aim to:

- evaluate reviews as a tool to build trust between users of a service, and
- understand which way to present reviews is more valuable for the users.

In order to do this, we developed another scenario for our fictional online sharing platform, this time we asked participants to act as borrowers of various personal possessions. Participants were presented with several profiles of fake users, their task was to decide whether to share a given article or not with each person. An example of a trial is shown in figure 18 (again, in spanish).

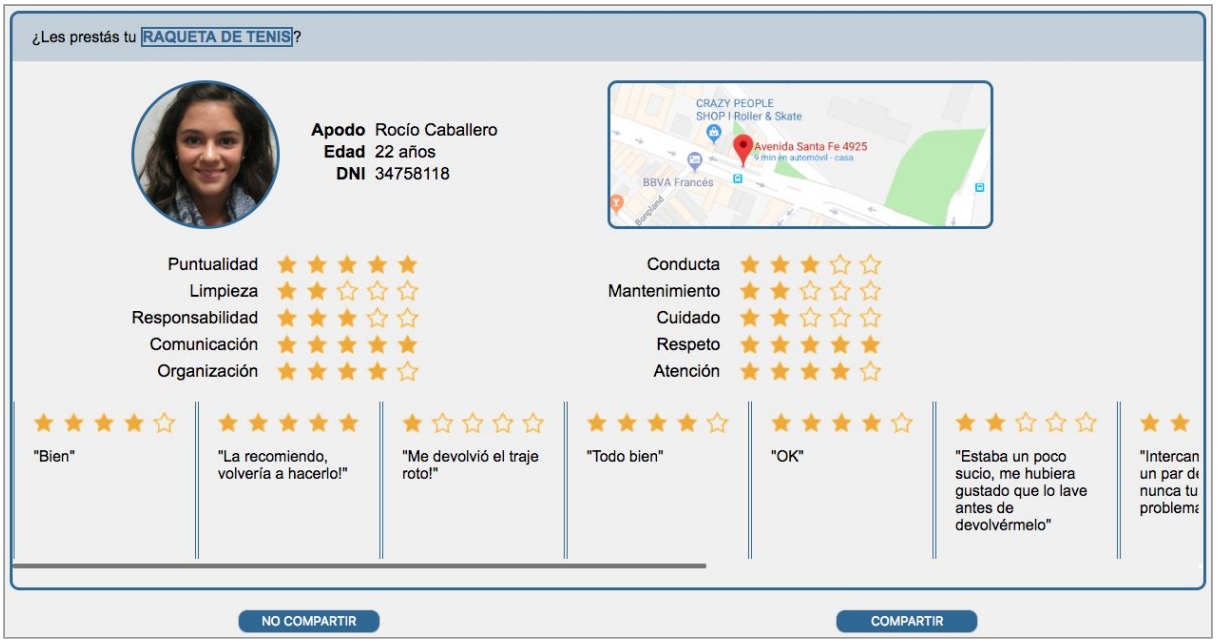


Figure 18 DC17 Test trial example

Every trial had both aggregated scores and comments describing previous experiences, each one presented using 1-to-5 stars scales. The amount of information to explore varied between trials, and also the fake users' opinions (good or bad) showed in the profiles.

The strategy was to quantify the amount of time participants spent watching the score summary and the comments section, in contrast with other regions. Within the comments section in particular we were also interested in measuring if they paid more attention to comments or to scores. Again, we interpret the time devoted to a region as the level of interest for said section.

As in DC9 Test, we also performed a 5-points Likert-scale compliance survey to check if participants were satisfied with their decisions. This survey is shown in figure 19 (in spanish).

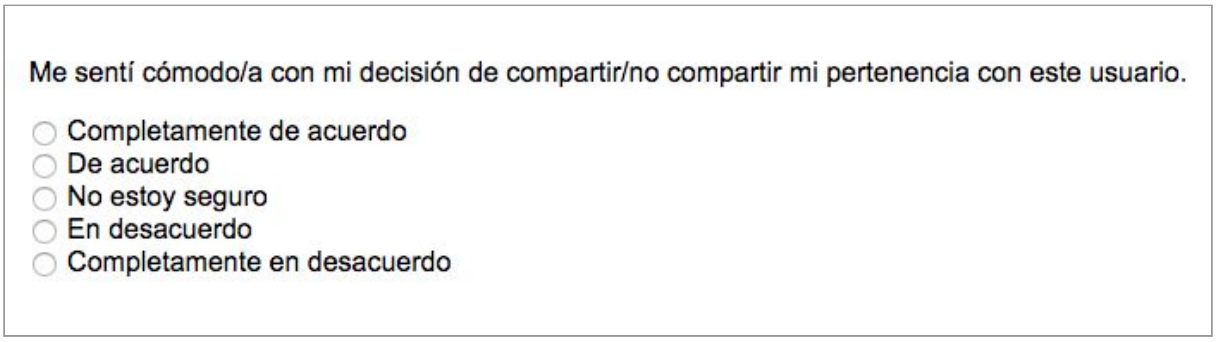


Figure 19 Compliance survey for DC17 Test

We envisioned participants were going to pay more attention to reviews than to other parts of the profile (such as the user's avatar) and that scores were probably not enough, we expected participants to read most comments, however we believed they would not read them extensively in the cases these exceeded practical purposes. We also presumed participants would be satisfied with their decisions on trials with at least one comment or score that stands out (very good, or very bad), and indicate having doubts when the reviews were mixed (good and bad), intermediate or confusing.

5.1.6.1.3. Trail Making Tests

In order to distract participants from repetitive trials of the previously described tests, we interposed the two parts of a visual attention test called Trail Making Test [Reitan 1955].

In both tests participants were asked to connect dots in a particular order using the mouse pointer. In the first one the order is given by a sequence of numbers (16 in our case: 1-2-3-...-16) and, in the second one, by an alternation of numbers and letters (8 of each: 1-A-2-B-3-C-...-8-H). We call Trail Making Test A to the first task and Trail Making Test B to the second one, examples of both can be found on figure 20 and figure 21.

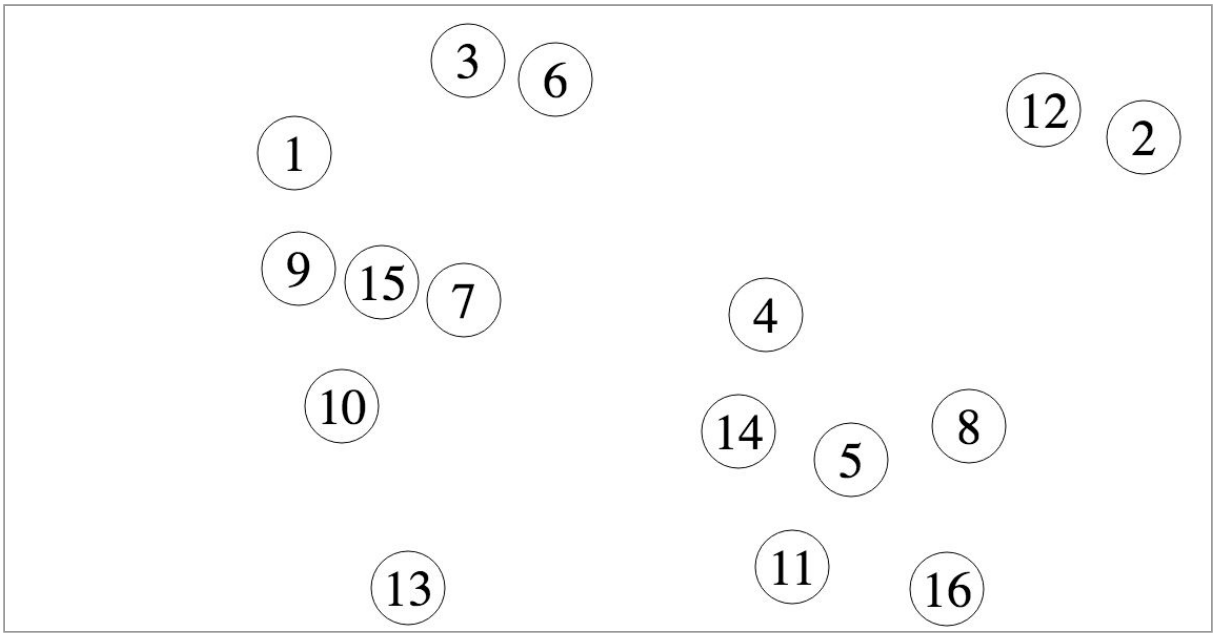


Figure 20 Trail Making Test A, connecting a sequence of numbers

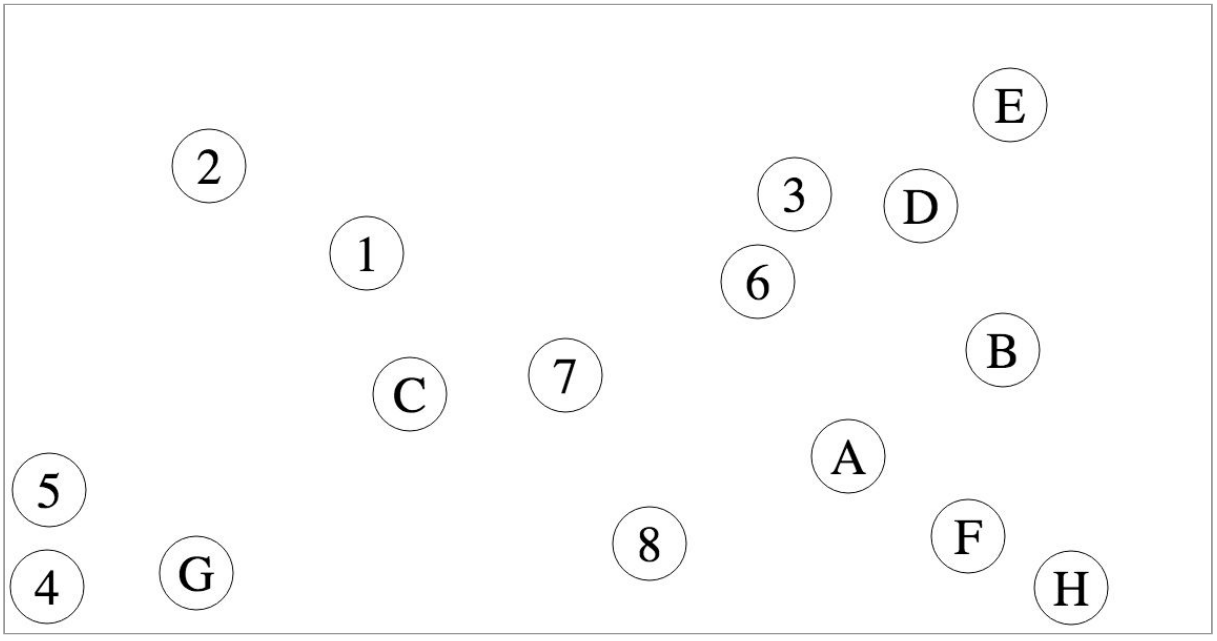


Figure 21 Trail Making Test B, connecting a sequence of numbers and letters

These tests proved to be particularly useful to adjust small eye-tracking imperfections, as we will see in the following section.

5.1.6.2. Observations

Most of our metrics depended on finding a way to measure how much time participants spent staring at each region of interest, therefore we had to be sure that the eye-tracking software and hardware were sufficiently accurate. To test this, we observed participants' eye behaviour during the Trail Making Tests. We chose to do it using these tests because it is easy to predict where the participants are going to look, and the regions of interest are well

defined. We also used Trail Making Tests to be certain that participants understood and were true to their tasks. We found 3 participants that didn't follow the experiment's instructions or had severe tracking issues, we discarded this data in future analysis.

The remaining 17 participants' measurements seemed to have small tracking errors. An example is shown from figure 22 to figure 24, where we exhibit eye movement, mouse movement and clicks during a trial of Trail Making Test A of one of the participants. Eye tracking seems to be slightly deviated (higher than expected), but enough to take samples away from regions of interest.

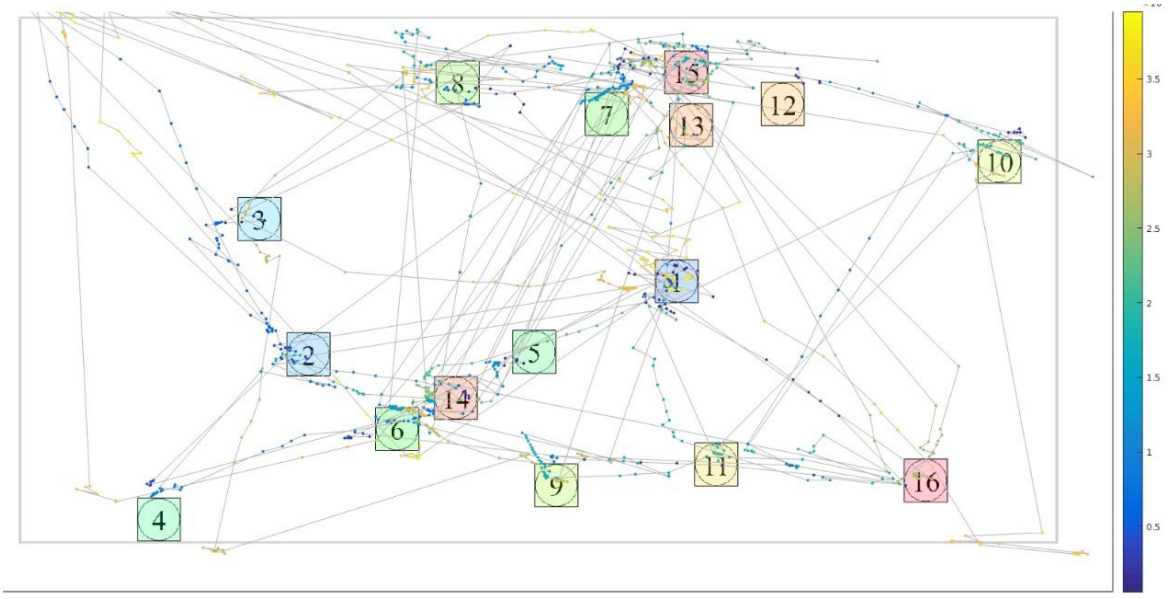


Figure 22 Eye movement; dots represent tracking samples; regions of interest and samples are colored according to a time scale (blue to red)

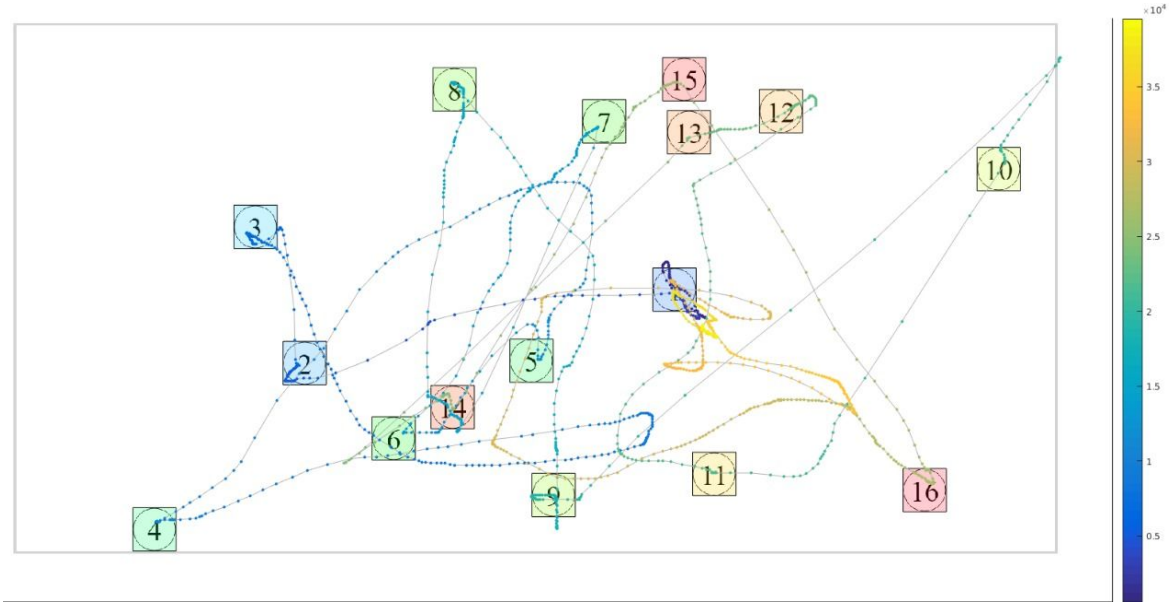


Figure 23 Mouse movement; dots represent tracking samples; regions of interest and samples are colored according to a time scale (blue to red)

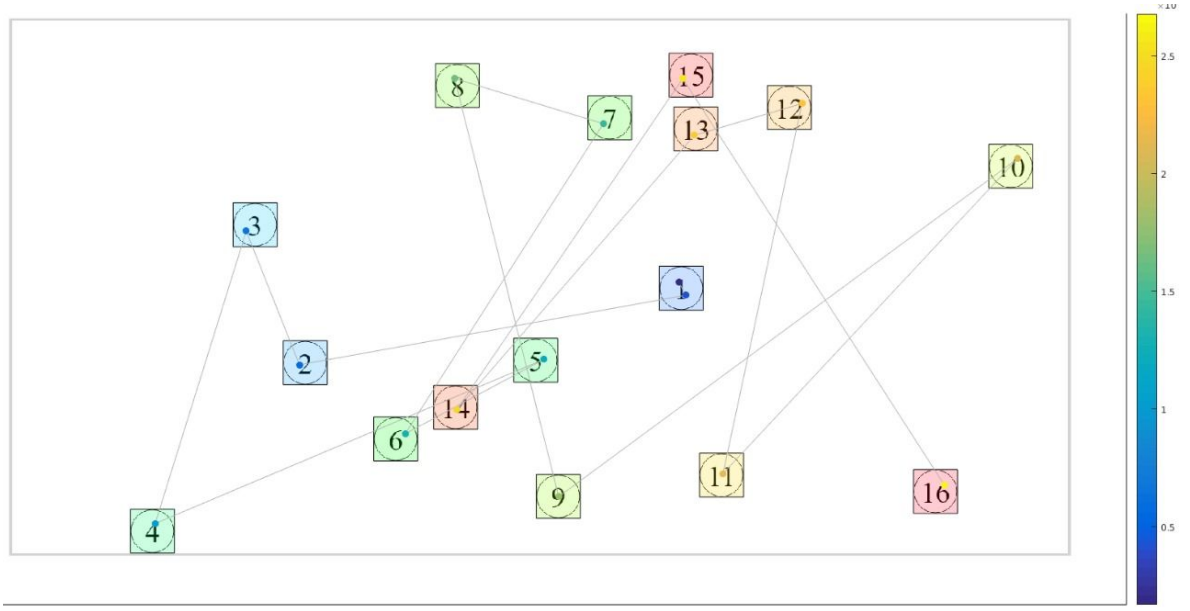


Figure 24 Mouse clicks; dots represent tracking samples; regions of interest and samples are colored according to a time scale (blue to red)

Trail Making Tests also allowed us to correct tracking deviations, we did it searching for the coordinates' offset that maximized the amount of tracking samples that fell inside some circle. Figure 25 shows heat maps aggregating Trail Making Tests trials for each participant, indicating the mean offset according to our correction algorithm.

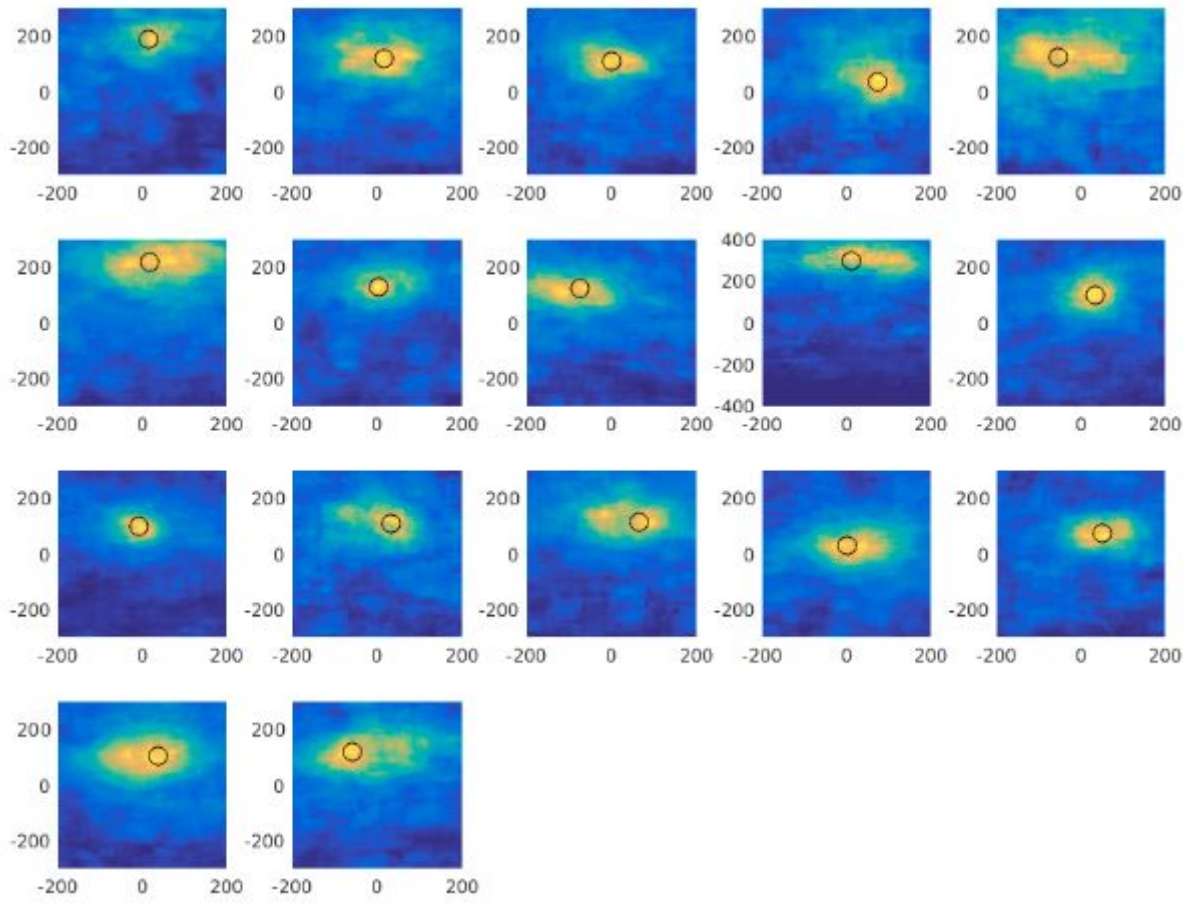


Figure 25 Eye tracking correction offsets for each experiment participant (in pixels); vertical and horizontal axis of each plot represent vertical and horizontal offsets respectively

Overall, tracking deviations seemed to be more noticeable in the vertical axis, as we can see in figure 26.

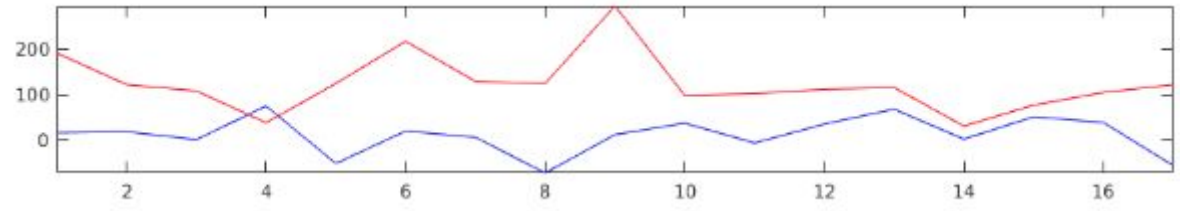


Figure 26 Eye tracking correction offsets for each experiment participant (in pixels); red corresponds to the vertical axis, blue to the horizontal axis

From this point forward, we applied the corresponding correction to each participant, over the data of every trial of each test. Thus, will read revised data from now on.

On a different note, other interesting observations we made exploring raw data from Trail Making Tests are that: (1) fixations (when the eyes are locked towards a point) appear to be more scattered than expected, and (2) saccades (the eye movements between fixations) have more samples than we anticipated, as if they were too slow (see figure 22). This may be due to particular behaviours imposed by Trail Making Tests (such as the eye following the

mouse pointer) or because of tracking inaccuracies. In any case, we believe this does not affect our analysis, which is based on time spent looking at wide regions of interest. However, it is worth mentioning the finding, as it might preclude some sorts of research where precision is more important and, thus, it is relevant to have it in mind for future analysis.

We have described how we leveraged Trail Making Tests to fit the gathered data. Now we turn to the actual observations about DC9 Test and DC17 Test.

5.1.6.2.1. DC9 Test

In order to make sense of the results of the test, it was necessary to aggregate the data from the 12 trials of each of the 17 participants. As mentioned above, we aimed to study how much time subjects spent looking at every single region of interest, as we expect participants to spend more time staring at avatars and addresses. However, we also decided to observe visit counts per region (how many independent times someone stares at a given section) and the probability for a certain area to be the first to be looked at. This metrics usually provide rich information in decision making processes. In addition, we studied all of these not only with the eye-movement data, but from the mouse-movement perspective as well.

The first step was to officially define the regions of interest (ROI). Taking into consideration dropdown menus and pop-up windows, we agreed on using the following definitions.

Figure 27 Regions of interest for DC9 Test

Immediately after, we needed to define several criteria to aggregate the data from every participant's trials. The rule was to take the average from the results of each participant, which in turn were computed as the average of their trials. Within a particular trial, we summed the time spent looking at a given region. The number of visits per region were calculated in a similar fashion. Finally, for the first visited region measure we normalized the amount of times each ROI was the first to be looked at.

Keeping all this in mind, we arrived at the following results.

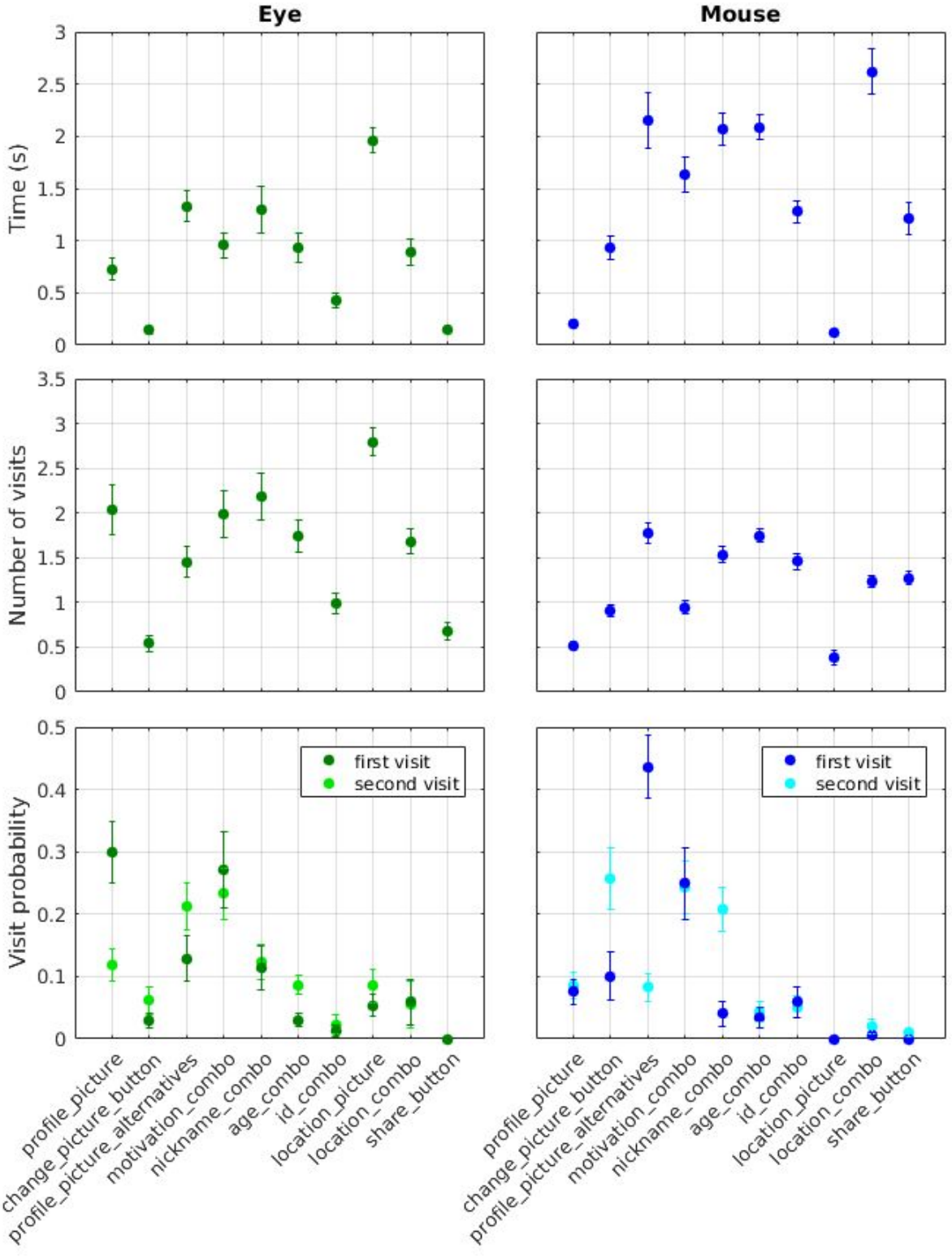


Figure 28 Aggregated eye-movement and mouse-movement data from DC9 Test; each point corresponds to the group mean (17 participants); bars represent standard deviations

Although there are plenty of interesting findings to discuss, for the purpose of our work and to stick to the planned statistics, we focus on the following observations, as we are going to perform comparisons drawn from the hypotheses only.

The gaze-time chart shows a relevant ranking: the location map is what participants spent the most time looking at, followed by the profile picture and the nickname, and then by motivation and age menus, finally the ID field and several buttons were the least watched. This seems to indicate that address data is the most sensitive piece of information, apparently people pay much attention to it. In a second place, but definitely still worth mentioning, the picture and nickname sections of the profile were relevant for the subjects. Finally, we understand the rest of the profile was not of much importance for our participants.

The same pattern displays at the eye's visit-counts and mouse hover time charts, although in this last one we see it on the interactive counterparts of the region, which is reasonable.

Looking at the visit-counts for the mouse we can argue that decisions are final most of the times, participants don't seem to hover over the same ROI two times.

The last two charts show a different order of relevance: most participants usually started paying attention to the profile picture and motivation regions, others looked at the nickname first, a few started with the location section, and the least started with the age and ID fields.

Seemingly, the first gaze is not necessarily related to interest, but rather to what is more attractive at a quick inspection. Further research might explore how to make sensitive information more attractive, so that users don't have to explore the interface to find what they want to set up.

As expected, we observed that users pay attention to revealing sensitive information (primarily one's location) to undesired audiences. We believe that personal data such as an address, revealing pictures and, surprisingly, one's full name may make users feel uncomfortable sharing. As discussed in previous sections, this could be due to privacy and trust issues related to safety and self-presentation concerns.

In order to verify the validity of this conclusion, we statistically tested the relevance of the location ROI against the other regions. We did this by contrasting the sum of the time spent looking at *location_picture* and *location_combo* regions versus *profile_picture* and *profile_picture_alternatives*, which combined represent the second strongest region. We performed a Wilcoxon Rank Sum Test with positive results, these are shown in figure 29.

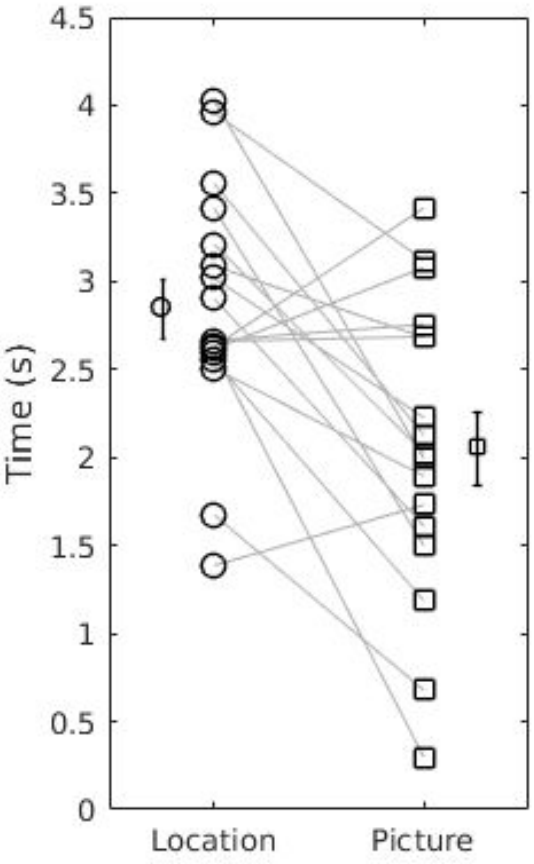


Figure 29 Wilcoxon Rank Sum Test: location versus profile picture fields;
p = 0.0230, z = 2.2733, d.f. = 17

In addition, we explored the answers to the compliance survey at the end of each trial to reinforce our speculation. We splitted the trials into two groups: those who allow to hide the users' exact address and the ones that do not support this behaviour. The results of the surveys are shown in figure 30.

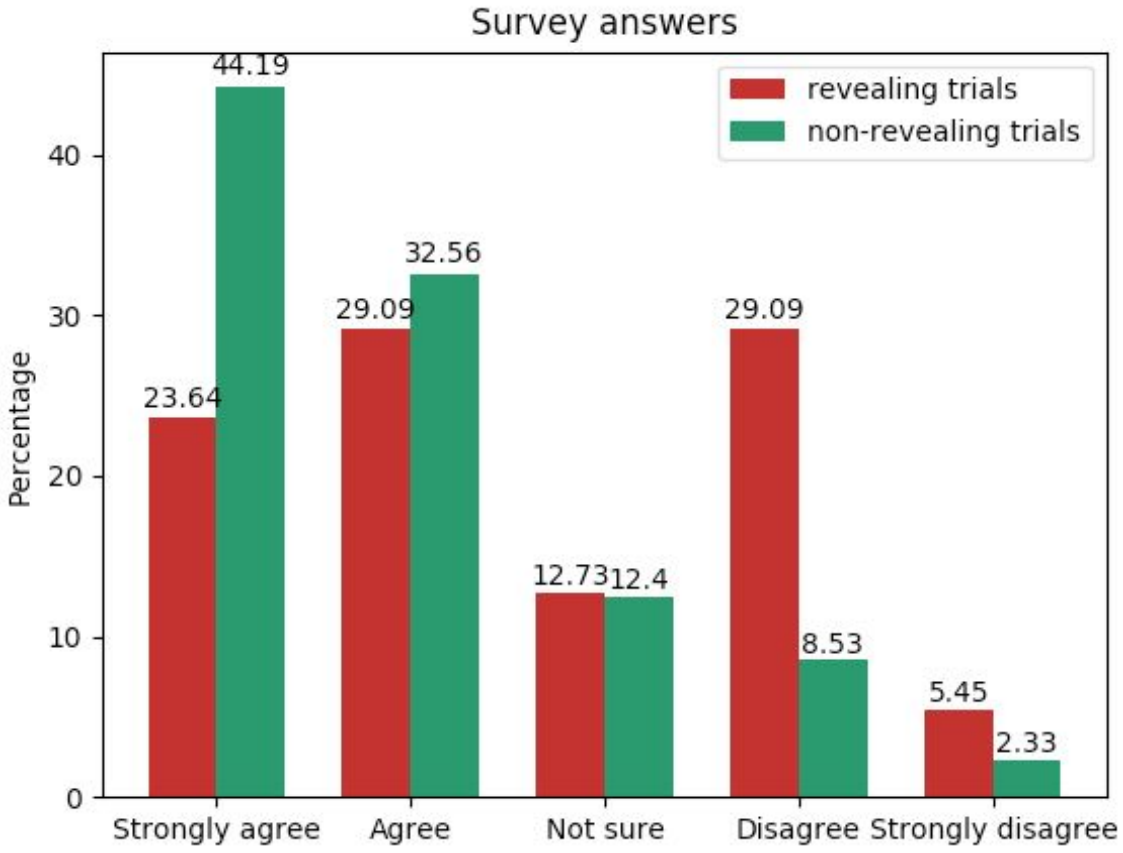


Figure 30 Compliance surveys for location revealing and non-revealing trials (those who allow to hide the users' exact address and the ones that do not support this behaviour)

Users appear to be less comfortable sharing in the cases where the ability to hide location information was disabled, which strengthens our speculations.

It looks like having diverse granularity levels to share sensitive data alleviates concerns on technology-mediated sharing practices.

5.1.6.2.2. DC17 Test

The process for making possible to interpret the data was the same as in DC9 Test. We used the regions of interest shown in figure 31, and arrived to the results of figure 32.

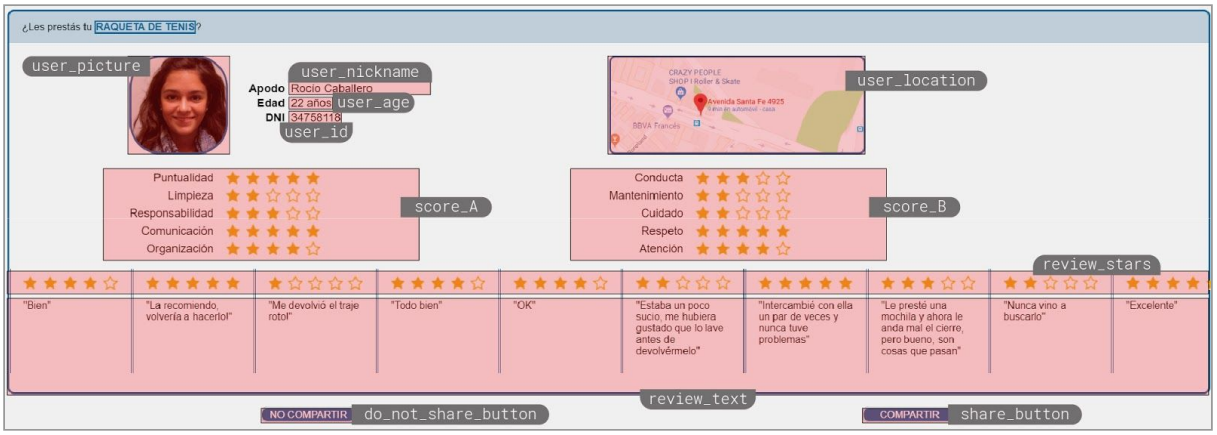


Figure 31 Regions of interest for DC17 Test

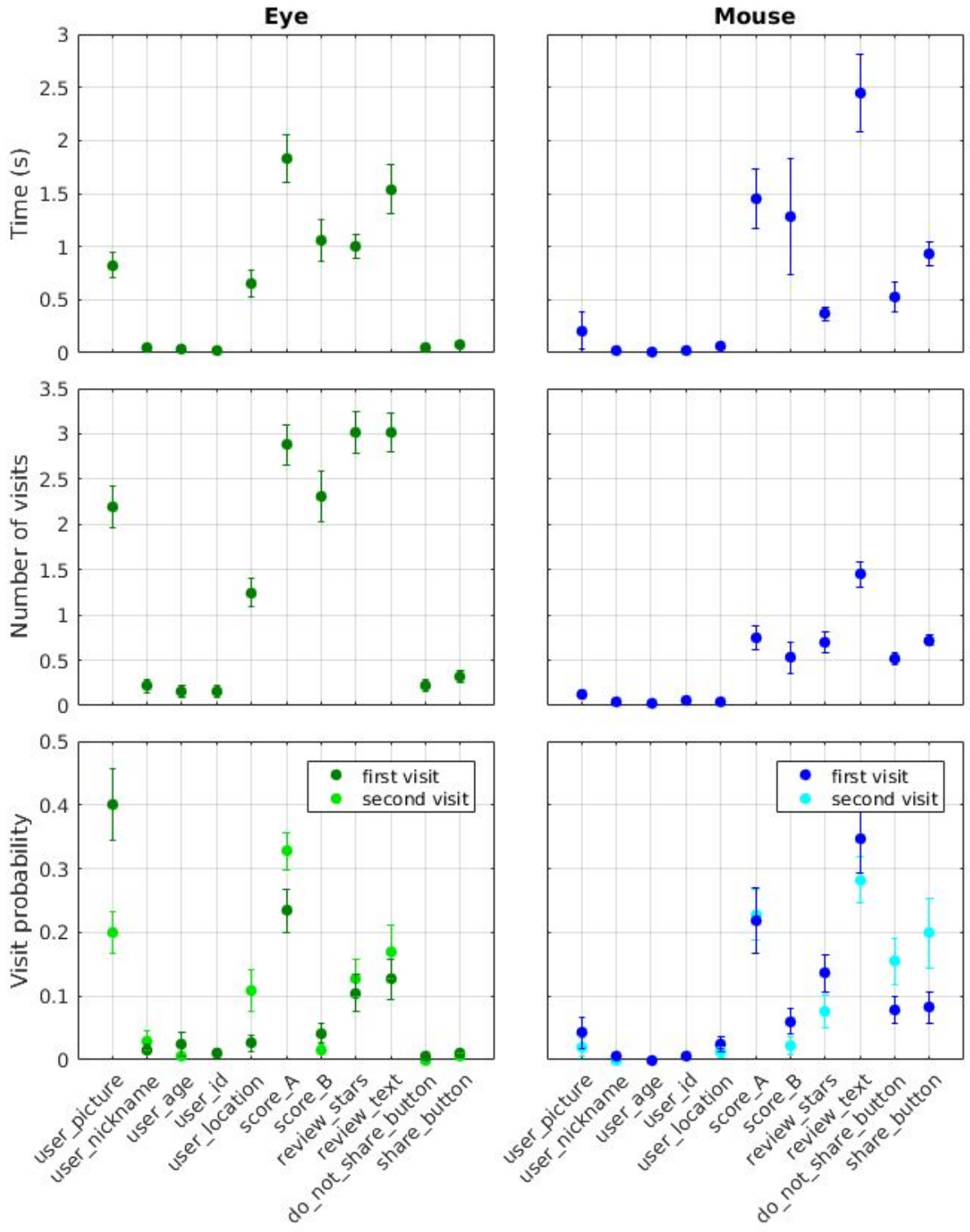


Figure 32 Aggregated eye-movement and mouse-movement data from DC17 Test

The first two eye charts suggest that profile scores and users' reviews are the most informative pieces of information at the time of sharing to unknown people. These seem to be more determinant than the personal information posted by the user.

Regarding to the comparison between these two mechanisms for displaying evidence of previous exchanges, it seems that participants spent more time gazing at scores, which is notable because reviews were lengthier. As a quick note, the *score_B* ROI was not present in every trial (some had five rows of stars instead of ten), so it is reasonable for its value to be lower than the one of *score_A*.

Having scores to summarize past experiences appears to be appreciated by users. However, reviews received a fair share of attention, we believe they could be necessary when profile scores are confusing or don't have particular information the user is interested in.

Further research is needed to confirm these thoughts. Future studies could be designed to understand the concrete data users expect to see in profile scores, and to observe if users stop depending on reviews when they have everything they need in the score summary.

Observing the third and last eye chart, we again noticed that the profile picture gets most of the participants' attention at first, even though this may not be critical to decide whether to participate in an exchange with the other user, which is consistent with the findings of DC9 Test.

In second place we see profile scores' ROIs and, after that, users' reviews. Other personal information fields take the last place in the ranking. All of this is compatible with the previous observations.

Finally, a curiosity we noticed looking at the mouse charts is that they turned in favor of reviews, we believe this is the case because participants followed the reading with the mouse pointer. Future research in interaction design could explore how to leverage this finding.

Overall, scores and reviews appear to be fundamental parts of a public profile in technology-mediated sharing services, these sections are far more relevant than personal information. Reviews may be a useful complementary resources for the score, which summarizes users' past experiences.

As we did with DC9 Test, we performed two Wilcoxon Rank Sum Tests to reinforce these conclusions. This time we compared personal information against evidence of previous echanges, and star scores versus reviews. For the first one we took the average of the gaze time of *user_picture*, *user_nickname*, *user_age*, *user_id* and *user_location* ROIs and compared them with the average of *score_A*, *score_B*, *review_stars* and *review_text*. For the second one we contrasted the average of *score_A* and *score_B* against the average of *review_stars* and *review_text* times. Results were positive for the first comparison, and not statistically representative in the second case, these are shown in figure 33.

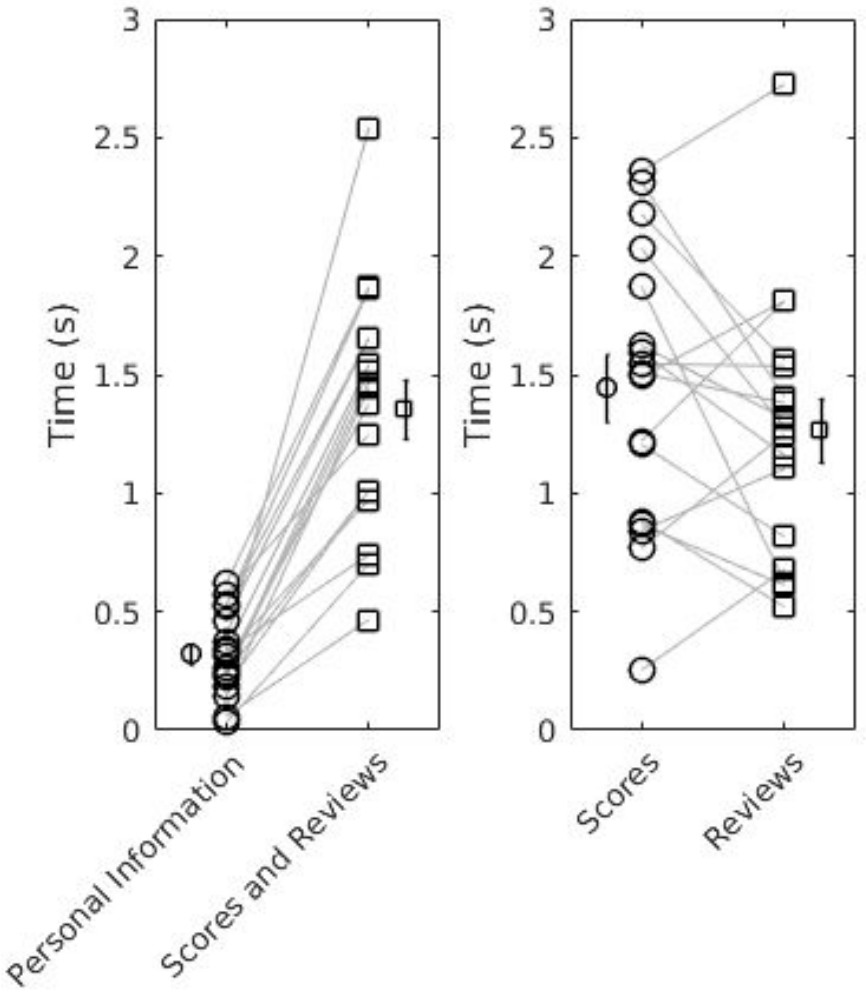


Figure 33 To the left, Wilcoxon Rank Sum Test: personal information versus scores and reviews fields; p = 0.0000014, z = -4.8221, d.f. = 17;
To the right, Wilcoxon Rank Sum Test: scores versus reviews;
p = 0.2557, z = 1.1366, d.f. = 17

Another hypothesis for this test was that participants were going to indicate having doubts when the reviews were mixed (both good and bad comments present) or confusing. We used the results from the compliance surveys at the end of each trial to explore it.

We clustered trials into two groups: the ones with mixed opinions in their comments and those with similar reviews. Answers to the surveys are shown in figure 34.

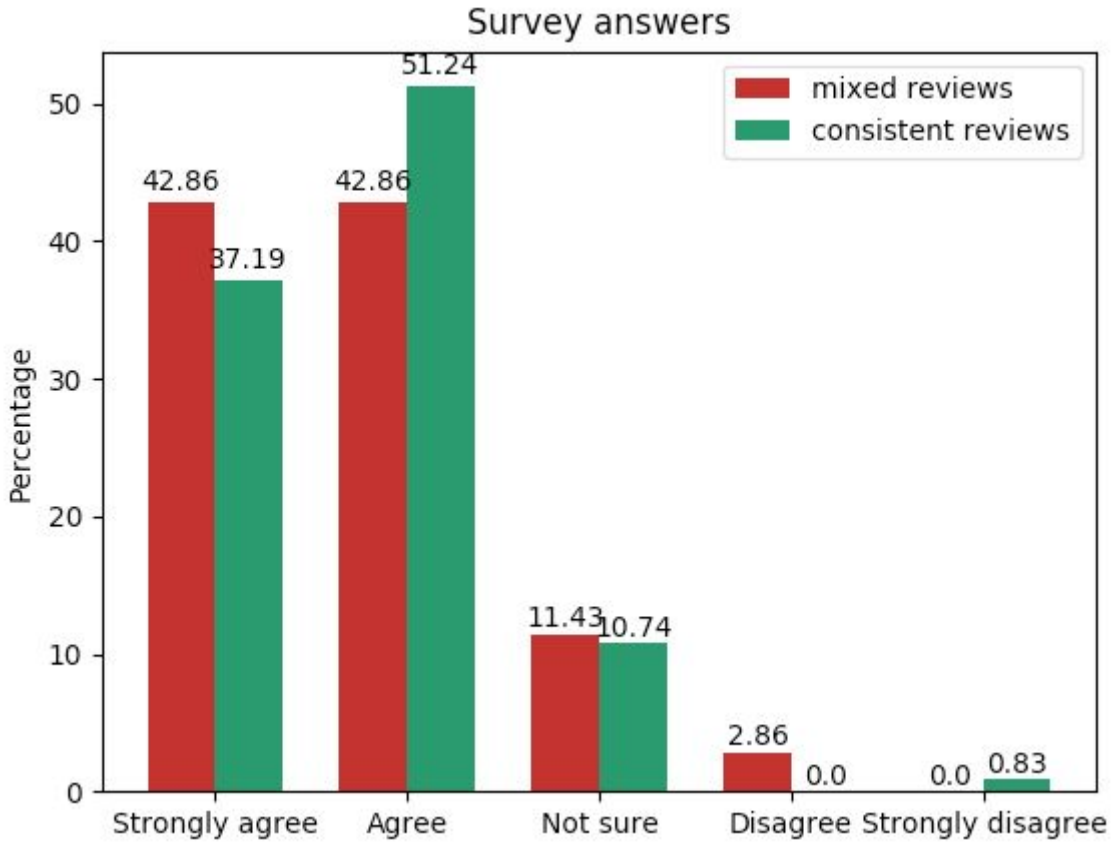


Figure 34 Compliance surveys for trials with and without mixed opinion in their reviews

Unfortunately these results are not conclusive, as there is no visible pattern distinguishing both sets of trials. Future research might explore this aspect in depth, it is necessary to design an experiment specifically for this purpose, paying special attention to the made up comments.

In summary, along these two examples we explored how to design experiments to evaluate existing tools, or to develop novel features of online sharing platforms, everything guided by the design considerations proposed in this work.

Additionally, and although it wasn't our goal, we noticed that this type of research may also be useful to build new design considerations based on unexpected findings. In future research we could repeat a similar process with all our current design considerations and formalize findings into new recommendations.

5.1.7. Conclusions

Throughout this section, we built and put in use a set of recommendations for evaluating and designing novel technology-mediated sharing services, in particular for physical artifacts.

To accomplish it, we started by performing an extensive literature review, which was the basis to shape a framework for experience design for sharing practices, composed of five top-tier themes: Content, Audience, Motivations, Privacy & Trust and User Experience. In addition, we characterized previous work among Nicholas John's communicative and

distributive logics of sharing, and digital and physical types of shared content, which provides a better understanding of the scope of previous research in the subject.

This steps provided a frame for the next stage, where we compared the practices of sharing digital and physical artifacts online. We arrived to several interesting findings, which we reflected upon and, ultimately, triggered the design considerations. These findings were also complemented by quotes from actual conversations we had with designers and sharing domain experts.

Finally, we developed a set of recommendations in the form of cards designed for practical use in actual design environments. We ended up by showing examples of use of two of the cards, in an experiment that also helped to strengthen our speculations. We are optimistic that researchers and service designers will find this considerations useful.

5.2. User experience

As this thesis revolves around experience design, we believe it is pertinent to deepen our understanding of the User Experience component of the presented framework. This is the purpose of this section.

In what follows, we develop this particular theme more deeply, building a more detailed understanding of its components and looking for relationships with other of the discussed models in UX research. We also provide concrete examples on how to use this piece of the framework in actual design projects, and arrive to conclusions about several aspects to pay attention to when designing sharing experiences.

5.2.1. UX dimension: relationship with other models

Forlizzi & Ford 2000 [Forlizzi and Ford 2000] describes *experiences* as constant streams that happen during moments of consciousness. In the context of *experience design for sharing practices* we are interested in the *users'* experiences in relation to the activity, this is what the *User Experience* dimension of the framework represents.

Forlizzi and Ford state that in order to achieve specific goals within these streams of consciousness (to leave a good impression, to impact positively), service creators design in terms of *an experience*, a smaller part of experiences that has a beginning and an end, and changes the user and, sometimes, the context of the experience as a result. This is what the *Experience* sub-theme of the dimension represents.

Finally, according to the same authors, *experiences as stories* are a way to communicate experiences, the vehicle that we use to condense and remember them. Designers use stories to understand previous experiences and their implications. *Context*, *Interactions* and *Experience* describe *experiences as stories* within our model.

Forlizzi's and Ford's three aspects of experiences are incorporated in the framework, they describe big goals (*experience*), smaller steps to that goal (*an experience*) and the means to achieve it (*experience as a story*). *An experience* is represented by the *Experience* subcomponent, adding *Context* and *Interactions* to *Experience* we describe *experience as a story* and, finally, iterations of these with different experiences (and, potentially, also with new contexts and forms of interaction) represent the *experience*, which is covered by the whole *User Experience* component (see figure 35).

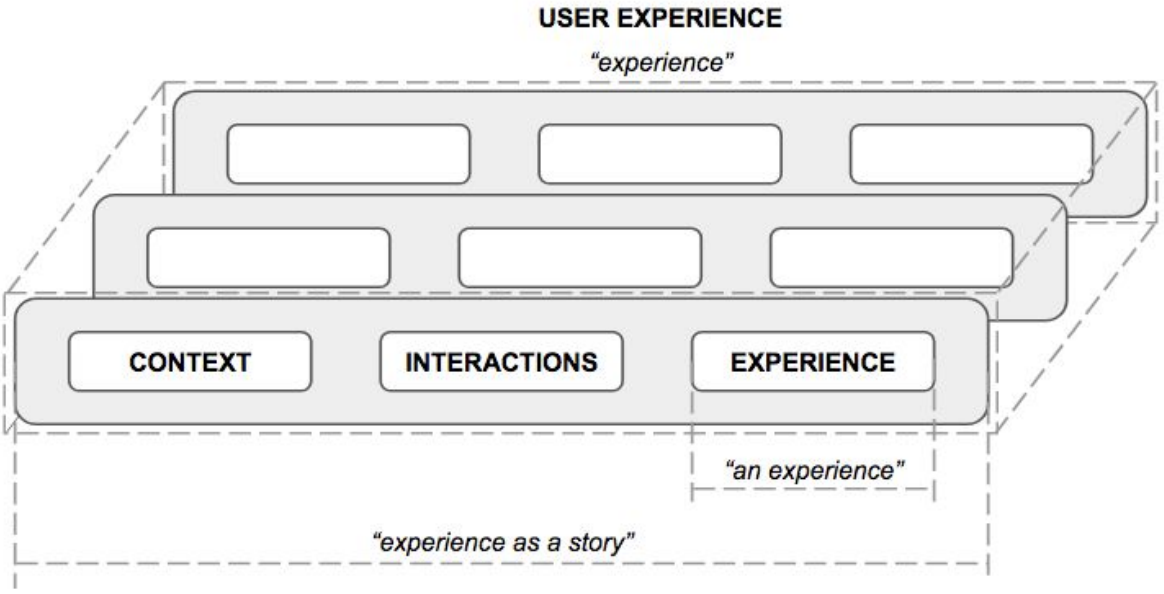


Figure 35 UX dimension compared to Forlizzi's and Ford's framework

Forlizzi & Battarbee 2004 [Forlizzi and Battarbee 2004] introduces three *types* of user-product interactions. *Fluent* interactions are skilled, *cognitive* ones result in knowledge or confusion and error, and *expressive* interactions help the user form a relationship to the product. For instance, the first time someone rides a bicycle one needs to understand how it works, these first interactions with the bicycle are cognitive. Once the individual learned how to ride the bike and after many hours of practice, the interactions become fluent and it doesn't take much attention to ride it. Lastly, an example of an expressive interaction would be the one experienced when repairing or painting the bicycle in a different color.

In Forlizzi & Ford 2000 [Forlizzi and Ford 2000], the authors argue that looking at the shifts between components is a useful way to begin to understand *types* of user-product interactions (i.e. fluent, cognitive and expressive), potential tensions arising from those shifts and dynamics between the elements. Experiences trigger changes in the interactions between the users and the product (for instance, cognitive interactions may build knowledge and thus following interactions could be fluent). Following Forlizzi's and Ford's recommendation, the UX dimension of the model considers these shifts as new *interactions* are created with each new layer, we call these *interaction shifts* (see figure 36).

The spatial and social *contexts* can change too, following with our model we refer to these changes as *context shifts* (see figure 36). We also incorporate the concept of *device shift* to consider multiple devices and users swapping between them (see figure 36).

The model also acknowledges that some of the components of UX don't always change, layers could keep aspects of the previous one, for example they could have the same context (see figure 36).

If any of these shifts occur in a shared environment, Forlizzi & Battarbee 2004 [Forlizzi and Battarbee 2004] and Battarbee & Koskinen 2005 [Battarbee and Koskinen 2005] call them *co-experiences*, the term describes experiences in social contexts, where interpretations are influenced by the presence of others. Because sharing is a social

practice, layers of the UX dimension of the model could be associated with a co-experience (see figure 36).

Forlizzi & Battarbee 2004 [Forlizzi and Battarbee 2004] also states that designers should consider emotions as input and output for experiences, arguing that interactions can be characterized by a particular emotional response, which is ultimately stored in memory as a particular aspect of an experience. To consider possible emotion biases, the layer division in the UX dimension of the framework also illustrates this finding, relating emotions to previous and subsequent *experiences* (see figure 36).

As this dimension of the model follows the evolution of UX over time, we also include findings from Karapanos et al. 2009 [Karapanos et al. 2009]. The authors state that product adoption consists of four *phases* (*anticipation*, *orientation*, *incorporation* and *identification*), and three *forces* (*familiarity*, *functional dependency*, and *emotional attachment*). Experiences that happen prior to any actual experience of use and build expectation are part of the anticipation phase, orientation refers to users' initial experiences (which may be exciting and frustrating, as they experience novel features and encounter learnability flaws). In the incorporation phase users reflect on how the product becomes meaningful in their daily lives. Finally, experiences that involve the product communicating parts of the users' self-identity are part of the identification phase.

An increasing familiarity with the product would be responsible of shifting from the orientation phase to the incorporation phase, an increasing functional dependency would be capable of making the transition from incorporation to identification, where, finally, the emotional attachment with the product would be the appreciated quality.

We incorporate phases of adoption as groups of layers within the UX dimension (see figure 36), and encourage designers to consider the three different forces and how they vary with each experience (in the *experience* sub-theme, we do not explicitly include them in the figure), e.g., within the orientation phase, episodes that cause stimulation are satisfying, however learnability flaws may cause familiarity to diminish.

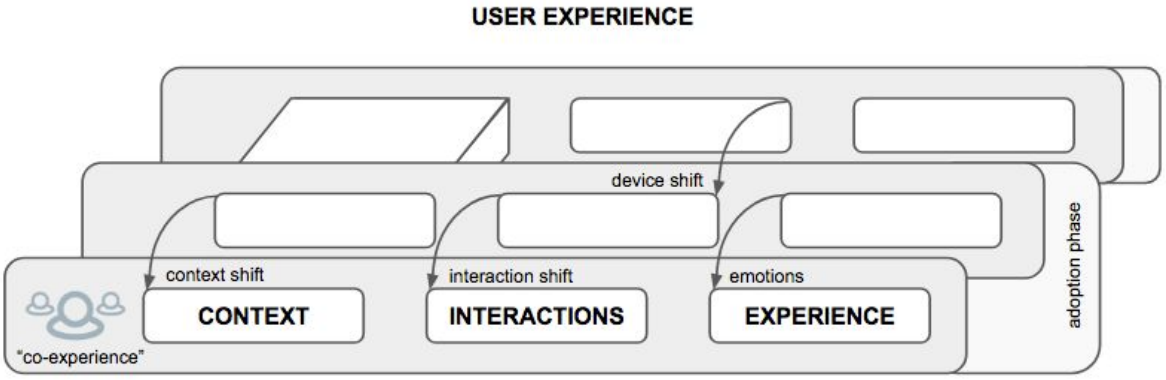


Figure 36 Experience shifts

5.2.2. Use case scenario

The previously discussed concepts are better understood by examining a concrete use case scenario. The following example follows a user through her journey using an online workout sharing service.

1. Alice decides to start regular jogging after work, she gives it a try at a park close to her home. She enjoys it and wants to do it again.
2. This time she downloads an app on her phone to track her exercise. Alice is not happy with her performance. However, she likes her new app, although it was hard to understand the interface at first.
3. Back at home, to motivate herself, she uses the app to share her plans for the next day, she is going to the park for another run. Through comments within the app people provided their interest, and she even finds a running buddy, Bob. She is now much more confident with the app and its interface.
4. Her next run she has company. Bob runs besides her and tracks his exercise using the same app in a smart watch. While running, Bob asks Alice about the app's interface for mobile phones and Alice describes her first impressions. This time her exercise's performance is much better and she is happy.
5. When she arrives to her home, she decides to turn on her PC to share her running experience with her friends through the service's platform.

The previous experience and interactions with the app are represented in figure 37, where we can see some relevant aspects of the context, the interactions and the experience, as well as some of their shifts.

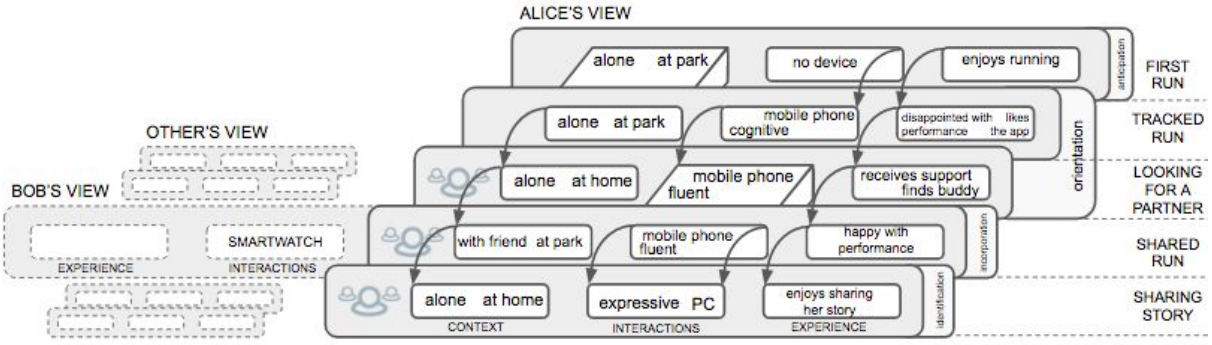


Figure 37 Workout sharing mediated by online service

The picture can get bigger and more detailed as new elements are considered within each component, and incrementing the granularity by adding more layers to the analysis. The framework and, in particular, the UX dimension are flexible enough to represent multiple scenarios with diverse levels of detail.

5.2.3. Conclusions

UX researchers agree that "a successful design will take into consideration all of the components in the user-product interaction: user, product, and context of use" [Forlizzi and Ford 2000]. We believe that the framework informs how to do so, not only including these

aspects as crucial, but also considering previous experiences, changes in interaction, learning from stories, social aspects of sharing, and product and context specific qualities such as which devices the users manage and what triggers them to share. These are the focus of the UX dimension, however, other dimensions of the model also pay attention to the user (e.g., Motivations), the product (e.g., Content), and the context (e.g., Audience).

The dynamic nature with which users experience the service should be taken into account. Looking at how interactions evolve is a useful way to begin to understand the user-product interactions [Forlizzi and Ford 2000; Forlizzi and Battarbee 2004]. Experiences trigger changes in the interactions between the users and the product. Designers should study the users' interaction shifts, and aim for fluent, cognitive or expressive interactions depending on the needs of the service. Components of a service with fluent interactions are intuitive, comfortable and easy to use; when interactions are cognitive, the task requires attention and builds knowledge; expressive interactions build a relationship between the user and the service and the rest of the community. The framework re-states the importance of such needs and considerations suggesting a way to look at emotions, context and interactions using the concept of *shifts* describing their dynamic nature.

Interactions can be characterized by a particular emotional response, which is stored in memory as a particular aspect of an experience. An emotion is related to other previous and subsequent emotions [Forlizzi and Battarbee 2004]. Although it may be difficult to include emotions in an analysis, designing for experiences requires to consider the users' emotions regarding to previous experiences with the service. Given that sharing is a social practice, paying attention to emotions is even more crucial, these may be more sensitive or influential because of the presence of others.

As sharing is a social activity, where experiences are created by groups of individuals, designers should take into account that experiences are shared between users, and the presence of other users influences outcomes from an interaction with the service [Forlizzi and Battarbee 2004; Battarbee and Koskinen 2005]. Special attention is needed in order to understand when this is something to take advantage or care of. For example, people might use a social networking site to ask for motivation to work out, the presence of others is positive in that case, however they may also feel indebted to the users that provided help, which may be negative if not properly handled.

Overall, the UX dimension of the framework is consistent with current trends in UX research, and we believe it may be a proper tool for experience design for sharing practices. Future research could put this to the test.

6. Final conclusions

We finish up by summarizing the contributions of this work, acknowledging its limitations and providing suggestions for future work.

6.1. Contributions

Based on an extensive literature review, we presented five main themes that characterize technology-mediated sharing practices in digital and non-digital contexts: (1) the diversity of shared content; (2) audience management; (3) motivations to share; (4) privacy and trust issues; and (5) user experience requirements. The last one we described it in depth. Using these dimensions, we described commonalities and differences within digital and physical sharing practices. We also offered a mapping of the design space for researchers who are interested in examining this topic further. Finally, we developed a set of design considerations in the form of cards for creating future physical sharing platforms and services, which we arrived at following the results of our comparisons and rich data from a set of semi-structured interviews; we also demonstrated how to leverage these recommendations by performing an end-user laboratory experiment.

Overall, we believe this work contributes to the academic studies on sharing practices, human-computer interaction and UX design disciplines, but also to the Web services industry because of the applicable nature of some of the displayed results.

6.2. Limitations

The results presented here, although organized and descriptive, are rather indicative and have to be interpreted with caution. Despite that we illustrate the results of the content analysis in the form of descriptive statistics, these should be read carefully, having in mind the method that we used is based on a qualitative account of a limited (albeit influential and emergent) amount of papers, which constitute our data corpus. Further empirical research within individual sharing spheres should be conducted to complement and develop our summaries and conclusions.

In order to minimize this limitation, we have: (1) conducted 16 semi-structured interviews with design practitioners and sharing economy experts to complement and develop our summaries and conclusions and (2) performed a laboratory experiment with 20 participants where we exploited our results to strengthen some of our speculations. However, both of these are also not statistical (or involved small samples), and the later was performed on just 2 of the 24 considerations.

Nevertheless, we believe that the research method we applied was systematic and holds up. We see value in providing a common vocabulary for researchers and designers to build novel sharing services online and offline.

6.3. Future work

In our view, the natural unfolding of the work presented here would be a participatory design process with service design practitioners based on the considerations we elicited. It would allow us to iterate the presentation of the recommendations into an improved, usable format.

It would also be fruitful to extend the scope of our end-user experiment to include all of the design considerations, in addition to working with the extracted data in a more statistical manner.

On a slightly different note, future research might deepen our understanding of each dimension of the presented framework for experience design for sharing practices, in order to arrive at a complete description for technology-mediated sharing.

Lastly, another potential research scenario involves contrasting our reflections against purely non-digital offline sharing practices, as we believe the space has not received much attention and could be valuable for this subject.

We invite researchers to reflect upon and to leverage the contributions of this work to build better sharing experiences in the Web 2.0.

7. Publications

Part of this work was published in the Proceedings of the 10th Nordic Conference on Human-Computer Interaction (ACM; September, 2018). The paper can be found at the ACM Digital Library with title *Supporting the Design of Sharing Economy Services: Learning from Technology-Mediated Sharing Practices of both Digital and Physical Artifacts* (https://dl.acm.org/citation.cfm?doid=3240167.3240203).

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