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Dealing with digital service closure

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People integrate digital services into their day-to-day lives, often with the assumption that they will always be available. What happens when these services close down? The introduction of services might be carefully planned, but their closure may not benefit from the same degree of consideration. A more developed understanding of the effects of closures might make it possible to minimize negative consequences for users. This paper builds on sustainability, digital memories, and collaborative-work research through an empirical investigation of service closure. Fifty-five participants completed a questionnaire that solicited experiences of service closure and attitudes toward prospective closure. Through a qualitative analysis of participant responses, we synthesized six themes that reflected the practical and emotional effects of service closure on people: disempowerment, disconnection, loss of capability, trust, time and effort, and notice periods. We make suggestions for ways that service features related to these themes might be managed during closure, but also identify less tractable challenges: as part of this investigation, we introduce and develop the concept of *service patinas* to describe the important but entirely service-bound data that contextualize digital artefacts.

CCS Concepts: • **Human-centered computing** → **Empirical studies in HCI**; Collaborative content creation; Social networking sites; **Empirical studies in collaborative and social computing**.

Additional Key Words and Phrases: service closure, service design, service patinas, collaboration, obsolescence, sustainability, digital memories, digital consumption objects, sharing, social media, data rights

1 INTRODUCTION

People rely on digital services to make friends, to collect and curate memories, to work, to meet potential partners, to buy things, and to while away a few hours. For many people, these services are essential infrastructure for their lives. This paper is concerned with what happens when these services close. How do people adapt to the practical impacts of service closure? Beyond just the logistical challenges of losing a service, what are the emotional effects of closures on users? These are increasingly important questions as collaborative work and leisure activities are increasingly mediated through remotely hosted, remotely controlled services. There is little guidance for service designers about the challenges that service closure creates for users, meaning the experience of closure can be more difficult for users than it might otherwise be. If we could begin to answer these questions, we could start to develop patterns for service closure that would minimize disruption to users.

We don't yet have many answers to questions about service closure. The literature describes planned obsolescence from a sustainability perspective [21], reports on long-term storage and curation of digital memories [55], advises on managing change aversion when interfaces are updated [63], explains why people *decide* not to use services [2], and shows what happens when people stop using them because they have died [46]. This literature provides helpful context, but does not cover scenarios where users lose access to services for reasons beyond their control. Service closure is not about users making active decisions to disengage. Service closure is something that happens *to* users. Empirical investigation is necessary if we are to understand the characteristic effects of service closure and develop proposals for improvement.

We conducted a study to investigate how service closure affects people practically and emotionally. We produced data on experiences of service closure and also speculations on potential closures. Using a questionnaire, we asked participants to recall a time when a service they were using

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had closed. We asked them to describe their emotional reaction to closure, how they adapted to practical challenges caused by the closure (e.g., finding new services, changing how they did things), and about their satisfaction with their post-closure arrangements. We asked participants who had not experienced service closure to choose a service they currently used and imagine that it were closing. We identified six themes in participants' responses that captured the practical and emotional dimensions of service closure: disempowerment, disconnection, loss of capability, trust, time and effort, and notice periods. From our results, we describe how services could be designed to close in graceful ways that minimize negative emotional and practical effects on service users. We also outline the hard challenges in this area, introducing the concept of 'service patinas' to describe the valuable data produced through long-term service use that is effectively impossible to migrate to other services.

2 RELATED WORK

The appearance and disappearance of digital services is a feature of the internet economy¹. Digital services are an essential feature of day to day life for things like payments [30], organizing family life [53], and keeping track of physical activity [28]. Services have, we think, a responsibility to consider the consequences of their withdrawal for users.

The ways in which people respond emotionally and practically to the closure of digital services have not been investigated, though there are adjacent literatures that help us to understand the ephemeral nature of both services and the people who use them. This helps us frame our questions in the context of work that recognizes the temporality of the technology that we interact with and the apparent lack of control that we have.

2.1 Obsolescence

Digital technologies become obsolete. This is especially the case for hardware, which over time loses software support and can eventually become non-functional. This obsolescence can be planned, in that companies intentionally stop supporting their product to induce (or require) people to buy newer replacements, or it can be a feature of rapid innovation that leaves older devices unable to interface with newer standards that subsequently become ubiquitous.

Amazon's 'Dash' buttons are an example of designed-in hardware obsolescence. They are used for ordering things like washing up liquid, small toys or toilet tissue and come fitted with a single-use battery. The battery is good for around 2,000 clicks and when "[...] the device battery runs out of charge, there is no way to recharge or replace the battery"². Moreover, these buttons are hard-coded to interact with Amazon Web Services. Were these services to close (or change in ways that broke compatibility), the buttons would be unusable. This kind of obsolescence is common for Internet of Things devices [72], where the low material cost of devices, the challenges of distributing updates and the sheer quantity and variety of devices makes keeping devices from falling into obsolescence difficult and poorly incentivized. As Rosner and Ames show, even when people *want* to be able to repair things, "manufacturing limitations, access to repair parts and expertise" [61, p.319] mean that they can't.

In human-centred computing (HCC)³, obsolescence is a concept that appears frequently in investigations of sustainability. DiSalvo et al. [21] describe the breadth of sustainability research, which includes work on persuasion and awareness. Other work has, for instance, focused on

¹<https://killedbygoogle.com/>

²<https://aws.amazon.com/iotbutton/faq/>

³Work in this domain has appeared in the human-computer interaction (HCI) and computer-supported cooperative work (CSCW) literatures. We make use of the broader term 'human-centred computing' to capture the breadth of venues at which research papers on this topic are published.

reducing material waste by finding new purposes for it (e.g., in 3D printing [20]), or on the sustainability of infrastructure [58]. Amongst the myriad of sustainability-related topics under active research, sustainable interaction design (SID) [5] is particularly critical of the role that HCC research methods play in enabling obsolescence and has most relevance to the problems we address in this paper.

Blevis's [5] concept of SID is designed to apply to goods with physical manifestations and the attendant waste produced by their obsolescence. Nevertheless, some aspects of SID are relevant to the closure of digital services. For example, the idea of 'salvage' might also usefully apply to the recovery of data from services that are closing. Blevis suggests that to minimize waste, the invention and disposal of devices should be linked. In other words, the development of disposal strategies should be part of the process of invention.

Cohn's work [15] on 'Geriatric Infrastructure' is highly relevant to our discussion of obsolescence. It examines how a space science mission approaching its end maintains the obsolete equipment required to sustain it. Cohn advances the idea that the "dying of an infrastructure is an active pursuit and indeed what lives or dies in infrastructure is always open to negotiation" [15, p. 1513]. In other words, which things disappear and which are kept going is an active decision, not simply a by-product of innovation. Where the end-of-life of an artefact is a choice, it means there is space for a process to manage the end-of-life with intentionality; there doesn't need to be anything accidental about how things become obsolete.

The HCC literature's handling of obsolescence often focuses on the negative effects of obsolescence at a societal level (i.e., over-consumption, climate change, environmental destruction). Here, we are focusing on a different kind of sustainability; whether a given service can be relied upon to function in the long term (i.e., whether the service is sustainable). Service closure of the kind we focus on in this paper is more individual and immediate, less wasteful in a material sense and, unlike, say, a smartphone losing support. It does not leave people with things that still might be useful – the service just ceases to be. Our focus is less on larger societal challenges of archiving, and more on how users feel about the closure of services they have built into their lives and the necessary strategies for people to work around such closures.

2.1.1 Ephemerality. Obsolescence is usually a long-term process that happens over years. An adjacent concept that researchers have been developing over a long period (see, e.g., [9]) is *ephemerality*; designing for interactions with services that happen and then vanish over short timescales. Most of the prior work on this concept has focused on chat tools like Yik Yak (which offered ephemerality mixed with geolocation and anonymity [62]), Snapchat (where messages are ephemeral and disappear after being read [3, 71]), and Instagram (which lets users decide on whether their posts should be ephemeral or not [13]). Xu et al. [71], for instance, explain how Snapchat's ephemerality helps people build smaller, more intimate networks, in part by reducing the burden created by the volume of mundane messages that close contacts might otherwise share. This kind of ephemerality has the potential to lessen the effect of a service closing, because there is no history, no collection of artefacts, that are threatened by its closure. One question that the literature does not answer is whether this kind of ephemerality reduces people's sense of vendor lock-in to a system. If more applications made users responsible for the long-term storage of their artefacts, as Snapchat does, what kind of challenges would service closure present?

Tsaknaki and Fernaeus [66] elaborate on the Japanese philosophy of *wabi-sabi*. One of the concepts in this philosophy is that impermanence is an essential characteristic of all things. Some examples Tsaknaki and Fernaeus use for impermanence – an ephemeral note-taking system and a robotic arm made of wood – are situated in ephemerality, with the goal of reminding users of their impermanence. Tsaknaki and Fernaeus describe this display of impermanence as been almost an

invitation because of the “explicit use of fragile materials and technologies, and that they thereby have been consciously designed to upgrade, repair, extend, and tweak, point to a shift in attitude compared to most other designs in this field” [66, p. 5976]. The key assertion of the work is that tools can be designed to make their impermanence salient to users, without compromising users’ ability to use them.

Work on ephemerality offers some ideas for reminding users of systems that systems are unlikely to last forever, but taking the kinds of approaches we have seen are likely to be challenging to implement in practice. Snapchat, for example, has made use of ephemerality in *parts* of its design, most obviously with expiring messages. But there is nothing about its design overall that implies that the *service* itself is ephemeral or about to vanish. Why would users want to invest time in a system that constantly reminded them that it might be about to end? Organizations want users to see their tools as dependable, so it’s difficult to see a way to straightforwardly graft learnings from work on ephemerality onto ways of dealing with service closure.

2.2 Digital memories and possessions

The collection, curation [69] and storage of digital memories has been an active area of research in HCC research⁴, often taking place under the umbrella of personal informatics [38]. These memories might take more obvious forms, like photos and videos, but they might also take less obvious forms, like data collected from activity tracking devices [22].

Odom et al.’s [55] work on digital heirlooms recognizes the challenges of maintaining digital memories over very long (i.e., intergenerational) periods of time. They suggest cloud-based storage might help ameliorate risks of lost or damaged devices, but their participants were concerned about cloud hosting, “especially in terms of ceding the higher-level social and moral work of safekeeping to a third party service.” [55, p.345]. It is interesting that cloud storage was seen (implicitly) by participants as reliable for very long term storage, and their concerns instead focused on other aspects of memory keeping. It is true that, in the short-term, people’s data is almost always safer from loss with a large cloud provider. In the longer term, though, service changes and closures might also create reliability issues for cloud storage, especially where not all data (e.g., interactions, comments, usage histories) is made available to users before a service closes.

The challenges posed by third-party vendor lock-ins to long-term memory storage are explored in detail by Molesworth et al. [48]. Although more resilient to technical failure, “hosted DCOs [Digital Consumption Objects] remain reliant on the persistence of their host websites, over which the consumer has no control, the result may be tense and stressful in comparison to the possession of fully owned material goods.” [48, p.257]. For Molesworth and colleagues, the structures of ‘DCOs’ are part of the market for digital services – users get locked-in and this allows for businesses to extract rents from them. This blurs the notion of ‘ownership’ when it comes to digital goods [70]. The design of these lock-ins makes a kind of business sense when a service is running. But when a service is scheduled for closure, this business sense evaporates and consumers are left with important parts of their digital memories disappearing⁵.

2.2.1 Thanatosensitive design. There has been a particular focus on the role of death in the digital possessions literature. ‘Thanatosensitive’ research [46, 47], which highlights the importance of

⁴This research is partly motivated by one of the author’s own experiences of using a platform for sharing photos and videos of their child. The service shut at short notice, and while the core artefacts – the photos and videos – were made available for bulk download, all service-level metadata (e.g., ‘likes’, comments), which also constituted an important part of the memories, were permanently lost.

⁵See <https://kotaku.com/playstation-3-ps3-vita-sony-digital-license-expire-chro-1848770979> for a recent example in which digitally purchased games on older consoles ceased to function because the consoles got confused about what the date was.

considering death and mortality within HCC research, was motivated by the realization that although new technology has historically been aimed at younger people, as the reach of these services grew, older people would increasingly be using them and the (presently) young user-base would age. For services with a non-trivial proportion of the world's human population using them, death through accidents and ill-health are also an important consideration across all age groups. Research in this area tells us that there are practical considerations for designing for this context, like data security [41], but also the acutely human aspects of memorialization [27, 45, 49, 52]. Even simple logistical aspects of death, like password recovery [57], are challenging to navigate and not generally well-supported in contemporary digital services.

Work on digital memories and death includes detailed design work with people in order to understand the different facets of presentation and remembrance after death; tools that might let people create posts that will appear fifty years in the future, or games to encourage people to curate content for after their death [11]. But what kind of platforms could support this kind of long-term usage? It is entirely possible that post-death Facebook notifications set-up now will run as expected in fifty years time. But it is also possible that Facebook does not exist, or that changes to the service mean that very old features begin to silently fail. Digital services are not typically designed, built, or maintained with multi-decade or multi-generational use in mind. Banks, for instance, have discovered (to their cost) that maintaining historic codebases over decades is a rather error-prone activity [14]. Approaches to thanatosensitive design encourage users to actively plan for the future when they are no longer alive, but there is no such emphasis on user planning for a future when the service is no longer active. Users can envision themselves not being around, but don't necessarily apply the same thought to the services they rely upon. Just as thanatosensitive design focuses on design at a user lifetime scale, in this paper we focus on design at a *service* lifetime scale.

2.3 Service closure

Denegri-Knott et al. [18] provide a useful interdisciplinary overview of the state of the art of research on digital possessions. It is worth noting that the *closure* of services that facilitate the storage and retrieval of digital possessions and memories is not something that receives explicit focus in this overview. In a sense, investigations of the closure of services provides the mirror of research that has largely examined how corpuses can be built, maintained and distributed. What happens when the medium for these activities is – sometimes suddenly – removed? Researchers have been working on the basis that we might want to look at photos taken today in 20, 40, 60 years. We might want to pass them on to future generations. We should not assume that the digital infrastructure that underpins our collection and curation of memories is persistent. It is not. Anticipating closure has to be intrinsic to how we think about digital memories and the services that facilitate their existence.

The coming and going of digital services is not new, of course, but the extent to which they are integrated into our day-to-day lives has increased significantly. Small services come and go, but some of the core services we rely on are run by 'tech giants'. What happens if Google decides to shut down its photo sharing service? The closure of even small services can be dislocating. In this work we will try to understand what people lose to these service closures and how they try to salvage and then incorporate things into new services. Cohn's 'geriatric infrastructure' at least gave its users the option of persisting with it [15], especially where specialist knowledge within an organization permits maintaining these kinds of systems [36]. When it comes to digital services where the host retains all control (i.e., Software as a Service, SaaS), choices over whether to invest in keeping obsolete systems working are taken out of the hands of users. Publications on SaaS generally highlight the benefits of SaaS for end users (e.g., low set-up costs, technical knowledge

not required, greater reliability), but, from our reading, generally do not address the risks associated with a service closing.

Services close for many reasons. The operating company may have ceased trading. The service may have fallen out of use. It may have been closed for more cynical reasons, like shutting down competition [65]. The reasons for a service's closure are not always transparent to users, but the end result is often the same: no access to services or the content hosted on them. In addition to outright closure, services might also be effectively closed to users by stealth, for example by a free tier being removed and payment being demanded after users are locked into a system, or free tier service levels being reduced after long-term use, such that the service as it was originally advertised effectively ceases to exist⁶. Mark and Semaan's [44] study of disruption to collaborative work tools provides some insight into the effects of short term 'closures' caused by disruption to technology cause by war or natural disasters. They found that people were resilient in the face of unavailability, but adaptations are not without cost; they require routines to be upended and less-than-optimal tools to be tolerated out of necessity.

It is not always the case that services are run-down or disused before they are closed. Services with large, active user bases often get closed. Google Reader was noteworthy for meeting this fate in 2013; when it closed, there was mass discontent across the internet [7]. So critical was Google Reader to some people's routines and work that the closure wasn't just inconvenient, it was an emotional event.

Service closure can represent a denial of access in a way that is perhaps similar to losing a physical possession, although, of course, digital services lack the materiality that is essential to the experience of losing physical possessions [29]. Berry [4] investigated people's experiences of losing physical possessions. One of the key differences between people affected by the closure of services and the absent-minded loss of possessions is that losing possessions means that people feel like they can't count on their "customary sense of competency" [4, p.228] because they feel responsible for the loss. This can't be mirrored in the closure of services run by third parties. However, Berry's 'Ways of Moving On' model is relevant to service closure. On discovering a loss, people can decide whether to search for the missing possession or not. This might be successful, or it might not. In addition to the practical aspects of loss, Berry describes the emotional content of the decision points and processes involved in loss; it is not simply the case that finding the object is wholly positive or being unable to recover it is wholly negative: "Yet counterintuitively, failure to recover the object may provide an escape from the burdens of loss, provided that individuals feel they have made a genuine effort." [4, p.242]. One of the things we're interested in discovering is whether people simply give up on certain features or functionality when a particular service closes.

2.4 Portability and service patinas

If the solution to a service closing is to find a similar alternative, then what are the challenges to doing so? Ribes [60] describes interoperability from a CSCW perspective, specifically data interoperability in the context of research. In this work, interoperability is described as "form of front-loaded practical work" [60, p. 1514]. In other words, having interoperability requires the foresight to realize it may be required and the incentive to allocate resources to it. Ribes also notes that interoperability is only ever partial because "what is interoperated by one standard or purpose may not suffice for another" [60, p. 1516]. Likewise, the *things-as-a-service* literature recognizes the portability challenges related to relying on remote, cloud-based services [31, 51]. Moving from one provider to another is difficult, because of the incommensurability problem: though two services maybe provide similar functionality, their implementations of core functionality will be

⁶We are grateful to an anonymous reviewer for raising this point.

idiosyncratic. In addition, core functionality may be accompanied by metadata that is bespoke to a particular service. This makes transferring between services difficult.

Data protection regulations, like GDPR, often demand that services turn over the data they hold about users on request. The reality is not so simple, though. Griggio et al. [26] investigated whether people moved to other messaging services after widespread concerns about a change to WhatsApp's privacy policies. They found that there were a number of barriers (i.e., lock-ins, implicit or explicit) that meant that almost no users migrated away from the service. These included network effects, app functionality, privacy concerns about alternatives, and the loss of their usage histories. Griggio et al. suggested message interoperability as a solution. This is the approach that the European Commission is taking to the regulation of messaging applications in its Digital Markets Act⁷.

It is not surprising that regulation is seen as the route toward portability and interoperability of data; data is valuable [59] to organizations. When people request their data, it is often provided in a form that might contain the relevant data, but in a largely unusable form [68]. It's not a priority to make export easy, and it might even suit companies to make it as difficult as possible (while still complying with the demands of regulators). But we also think it is a mistake to think that it will be possible to legislate away challenges of interoperability. Fundamentally, these are ontological questions, questions about the kinds of things that can and do exist inside services. There will always be a degree of incommensurability between services as they seek to offer unique services, or build their infrastructures in idiosyncratic ways. Some parts of services will be more amenable to being portable than others.

It's possible to see that recovering the primary artefacts users had themselves placed in the service (e.g., videos, messages, schedules) might be relatively straightforward. There is fairly clear user ownership of these artefacts. They are often discrete files, which makes them easy to package. Yet services often host substantial metadata that contextualizes artefacts and provide other core service functionality (e.g., comments, likes from other users). How can this kind of data be meaningfully ported across platforms, especially where other platforms have no way to represent this kind of metadata?

The challenges of portability in the context of service closure go deeper than exporting primary artefacts and metadata, because of the temporal aspects of interactions with services. Physical possessions acquire *patina* over time and with use. This patina reflects the story of a possession, and because it conveys a story, and the authenticity that comes with it, it is often a desirable characteristic of things. We'd like to argue that modern digital services closing could mean users also lose the 'patina' that is built-up with the long term use of a service. This patina includes the temporal framing of primary artefacts and metadata (e.g., being able to reference a photo on a service from a decade ago; being able to reflect on the comments on it), but also parts of a service that are less visible to users. For example, services often provide a degree of personalization to users based on their past interactions. This might include recommendations or bespoke search results that are the product of a user's interactions and a proprietary machine learning model. It might include the context around the conversations that are such an important part of collaborative work [23, 24]. This patina is accumulated over time from the use of a particular service, and is likely to be even harder than primary artefacts or metadata to transport to other services.

Imagine, say, a ten-year user of Spotify, a music streaming service, trying to migrate to Apple Music, another music streaming service. It's possible that libraries and playlists could be migrated. Likes on shared playlists could be migrated. With appropriate permissions and consent, 'friend' networks could be migrated. But one of the features that most music streaming services offer is

⁷<https://www.europarl.europa.eu/news/en/press-room/20220315IPR25504/deal-on-digital-markets-act-ensuring-fair-competition-and-more-choice-for-users>

music recommendations. These recommendations are based on users' listening histories, combined with primary artefacts and metadata. They are passed through proprietary machine learning models, which produce recommendations. The product of these models is a product of the patina that a user has collected over their decade interacting with a service. How could it be transported away from the service? Can we envisage a way in which a user could migrate to Apple Music, such that it would produce the same recommendations at the same moments? It is difficult to believe that it would be possible; this functionality is the result of the interaction of a user's patina and proprietary interpretations of those patinas.

These kinds of patinas are increasingly common across a range of services. Email systems can learn to prioritize messages based on past communication habits [16], for example. Messaging tools can learn which emoji users are most likely to want to press. Access histories can be used to create hierarchies of files in cloud storage tools. Search histories can be used to serve long-term users more accurate results. These patinas will become especially complex and contingent when they are based on the combined usage histories of multiple collaborators. Consider a document for which a service has tracked comments and changes by a variety of collaborators. There may be chat logs and linked media related to the document, too. If the service closes and only the document itself remains, how can collaborators hope to recontextualize the document if they don't have the service patina that represents their collective memory of the work that has taken place? The potential loss of these patinas seems to be an important but unexplored issue for CSCW systems. We will investigate this concept as part of our study.

3 OBJECTIVE

The aim of this research is to understand the emotional and practical effects of service closure on people. If we know how people experience these closures from emotional and practical perspectives, we will be better able to understand the value these services have for people and be better able to design for closure such that negative effects are minimized.

4 METHOD

4.1 Participants

An opportunity sample was recruited through the */r/SampleSize* [42] and */r/selfhosted* subreddits (i.e., communities) on the reddit platform⁸ and through informal (i.e., non-paid) advertisement on the Twitter platform⁹. Participants were incentivized with a prize draw. There was one prize of £50 (GBP), one prize of £20 and three prizes of £10. All but 12 participants elected to participate in the prize draw. We made no restrictions on location, and collected no location data.

Fifty-five participants completed the questionnaire¹⁰. Questions about age and gender were not mandatory. To minimize the unnecessary collection of personal data, participants selected their ages from a drop-down (18-24, 25-34 etc). Most participants fell into the 25-34 group; Table 1 shows the distribution of the rest of the sample. Gender information was collected through a free-response field. Of participants volunteering a response, 21 identified as women, 29 as men and one as nonbinary.

⁸<https://www.reddit.com>

⁹<https://twitter.com/>

¹⁰There were many more than 55 submissions made to the survey tool, we detail our processing of the submissions in the Results section.

Age range	Frequency
18-24	4
25-34	26
35-44	18
45-54	4
55-64	2
65-74	1

Table 1. Distribution of participant ages

4.2 Materials

Participants completed an online questionnaire, hosted on an instance of Limesurvey¹¹ controlled by the researchers. A favourable ethical opinion regarding the materials (and procedure) was obtained from a department-level ethics committee.

The questionnaire took a branching form, which meant that not all participants completed the same questions. We took this approach because we recognized that many potential participants maybe not have experienced (or recalled) the closure of a digital service. We were still interested to solicit their perspectives on the *prospective* closure of a service. Asking participants to imagine scenarios and reflect on how they might be affected is a common approach to understanding people's interactions with technology (see, e.g., [6, 12, 19, 32, 56]).

The routes through the questionnaire are illustrated in Figure 1. All participants worked through the study information, consent and then, at the end of the questionnaire, general items on their perspectives of service closure. After giving consent, participants were asked if they'd experienced the closure of a service. Participants' responses to this question determined which path they took through the questionnaire; either focusing on experiences if participants had experiences to report, or on perspectives on a prospective closure if they had not.

4.3 Procedure

Information about the study and the informed consent process were presented before the start of the questionnaire. Participants could not continue to the questionnaire-proper until they had checked a box to indicate consent. Participants could elect to leave their email address (for participation in the prize draw) and/or an individual (but not personally identifiable) code (e.g., 'star trek soliloquies') to retain their right to withdraw after participation. After consenting, participants worked through the questionnaire. Once the questionnaire was complete, participants were given a debriefing. As this work does not make use of deception (either directly or through omission), the debriefing was largely the introduction repeated with reminders of the withdrawal procedure.

5 RESULTS

Three hundred and ninety submissions in various stages of completeness were recorded at the end of data collection. The questionnaire was advertised publicly and, as a consequence, there were many incomplete, spam and blank responses. We assumed that participants who had made multiple responses, or had typed nonsense (e.g., 'asdf', 'no' in all boxes, copying and pasting the question as an answer) had not participated in good faith and removed their responses. We also removed responses where participants had made no responses to any free response questions (which comprised almost all the questions in the survey), assuming they had simply clicked through

¹¹<https://www.limesurvey.org/>

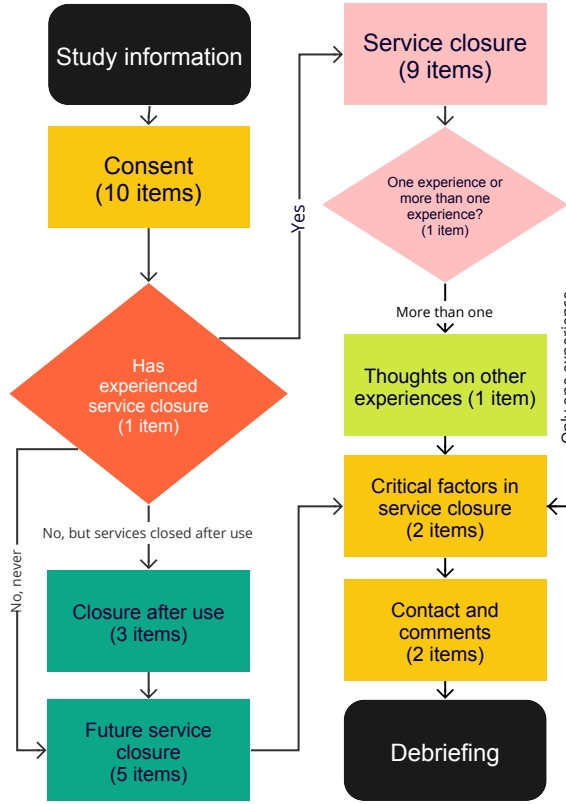


Fig. 1. A flow chart showing the structure of the questionnaire.

to the end. At the end of the process, 55 complete responses (i.e., 14%) containing legible responses remained for analysis.

The major decision point in the questionnaire was whether participants had previously experienced the closure of a digital service while they were using it (see Figure 1). Participants’ answers at this point determined which questions they saw in the rest of the questionnaire. Ten participants had experienced the closure of a service once and fifteen more than once (i.e., 25/55 had experienced service closure). Twenty-one participants had not experienced the closure of a service and nine had only experienced the closure of a service *after* they had stopped using it (i.e., 30/55 had not experienced the closure of a service as they were using it). There was, therefore, a fairly even split between participants who had experienced closure of a service while they were using it and those who had not.

As we have explained, asking participants to imagine how they would respond to the closure of a service follows in a well-trod tradition of asking participants to speculate about how a change might affect them. As the analysis will show, there are significant overlaps between actual experiences of closure and speculations on closure. Still, the experiences of those who have actually experienced closure are necessarily different from those who speculate about it, so we have annotated quotes from participants who indicated that they had experienced closure with an **E** (e.g., E-P1) and from those who were speculating with an **S** (e.g., S-P2).

Rank	Statement	Mean rank
1	Giving the opportunity to download user content (e.g., photos, videos, posts)	2.818
2	Giving a year's notice between announcement and closure	3.582
3	Making software available so that other people or companies can set-up a replacement	4.185
4	Giving a transparent explanation for why the service is closing	4.236
5	Giving suggestions for alternative services that would provide similar functionality	4.241
6	Giving the opportunity to download data on interactions with the system (e.g., search history, recommendations from the system based on your usage history, transaction history)	4.364
7	Giving the opportunity to download data on interactions with others (e.g., likes, comments from others)	4.491

Table 2. Ranking of statements about service closure from most important (rank of 1) to least important (rank of 7). We provide the means for reference, but as the input is ordinal these averages are only meaningful for establishing the aggregated rank.

We provide two main analyses of the data collected. First, we examine participants' rankings of important factors in the closure of services. Next, we provide a qualitative analysis of participants' responses to the free-text questions that comprised most of the questionnaire.

5.1 Ranking of important aspects of service closure

The final question in the survey asked all participants – regardless of how they answered earlier questions – to rank seven statements about the closure of services from most important (top) to least important (bottom). We developed these statements to reflect aspects of service closure that we have explored in our literature review. We produced an average ranking by taking the mean rank (one is high, seven is low) of the seven statements across participants. The results of this analysis are provided in Table 2.

5.2 Thematic Analysis

Most of the questionnaire comprised questions with free-text answer fields. These questions prompted participants to explain the emotional effects of the closure of a service on them, or what they think services might do to minimize the impact of closure on users. We analysed participants' responses to these questions qualitatively through a Thematic Analysis (after [8]). We consider the free response dataset as a whole when conducting this analysis, rather than attempting to code question by question. This means that participants' experiences and future projections of service closure are considered simultaneously. This ensures more robust coding that reflects the breadth of participants' responses (not all of which aligned neatly with the question posed). Note, participant numbers relate to tool-generated IDs and many are greater than the total number of participants included in the final analysis. The generation of initial codes was supported by the Nvivo 12 tool. Iteration on the data and codes led to the development of a set of six themes.

5.2.1 Disempowerment. One common theme in participants' responses was a feeling of being disempowered or helpless in the face of a service closing. On the closure of a service they used in order to share photos of their child, E-P6 wrote that they were “[...] still sad that this data was taken away from me - or rather felt like it was being held ransom for everybody's monthly fee”. The

entity responsible for disempowering a participant was usually the provider of the service, but it could also be a third party: *"I felt mad at record companies and the US government as I saw them as the primary reasons for Limewire shutting down."* (E-P75).

For E-P185, disempowerment came from the conflict between the sense of ownership they felt over their email address and the reality, which was that it was owned by the service provider and could be shut down unilaterally. They were left feeling *"[a]nnoyed that as a 20 year customer they could remove something that felt like mine[.]"* The feeling of intimacy and ownership accrued over long use being juxtaposed with what was perceived to be a remote and capricious owner was also a source of disempowerment: *"It was concerning that a core part of my daily routine could be removed on the whim of some unknown people on the other side of the world."* (E-P59). E-P306 echoed the sense of helplessness that came from being reliant on a service run by an organization that was entirely unresponsive to users. Discussing a data aggregation tool that they had helped to improve by providing feedback as an early adopter, E-P306 noted that the closure of the service they were using left them *"[...] frustrated and annoyed. Yahoo didn't even give the option to set it up as a paid for service, and they didn't release it as open source that could be maintained by what was an enthusiastic community."* To be left *"frozen out of using it"* (E-P306) without any say in how it was wound down after investing so much time and effort in the service was not a good experience.

5.2.2 Disconnection. The closure of services that facilitate social connections naturally means that those connections are weakened or broken. One of the themes we identified in our participants' responses was 'disconnection' from aspects of their social life after service closure. S-P304, for example, was concerned that if Facebook became unavailable that they would experience a loss *"of contact with some people"*. S-P259 makes the same point about losing the use of Instagram and WhatsApp: *"I feel I would loose connection with some people"*. Losing access to an email address meant that E-P185 *"[l]ost contact with anyone who only had that reference as my email address."* Several other participants (E-P195, E-P187) made similar comments about service closure cutting off direct communication with others.

Disconnection does not just entail a break in message passing, though. Services also facilitate feelings of presence in other ways. E-P65 was a heavy user of 'This is My Jam', a service that closed in 2014. They noted that they *"still think about it a lot, because it's the one internet service I want back."* One of the things they miss is the social connection generated by having a focus on a single track, rather than on playlists. This means that, for E-P65, in newer services like Spotify, *"there's not really a good way to pick up new tracks from friends."* The closure of This is My Jam disconnected them from this social sphere. As well as facilitating the discovery of new connections, services are also used for establishing a sense of shared presence among geographically disparate people. Closure damages these kinds of connections: *"Rather than ask all family and friends to start paying to see baby photos (we live far away from the majority of our family) I had to search for a new free solution"* (E-P6).

Digital services support people's hobbies and interests, so as well as losing connections with people, closure can mean people lose contact with particular aspects of their life: *"I lost touch with people I admired and respected, and stopped following some hobbies in as much detail being less aware of breaking news stories etc."* (E-P9). In this case, the closure of an RSS service (which we infer to be Google Reader) meant that hobbies that were facilitated through the service became disconnected from everyday habit and routine.

5.2.3 Loss of capability. Services closing left participants with a loss of capability – the disappearance of a service meant or would mean losing particular functionality associated with the service that may or may not be replaceable. In the comments from several participants the loss is a straightforward binary loss – they used to be able to do something with the service, and now they

are not: *“All my films were no longer available online, so had to resort to watching them on DVD/Blu ray”* (E-P300), *“The practical effect is that I lost out on a source of new music recommendations.”* (E-P65), *“If it is closed, I will not be able to get the work information I need from it, and my social communication will be interrupted”* (S-P46).

It was also the case that service closure did (or could) mean a partial loss of capability. S-P8 makes use of Garmin tools for activity tracking and, as a knowledgeable and experienced user, makes use of complex features of the tools. Losing these would mean a *‘[r]eversion to manual, broad, entry of running/cycling data’*. This would result in a *“complete inability to analyse finer details during the course of an activity (e.g. pace during a certain PART of a run.)”* The closure of HearJapan, a tool for discovering Japanese music, *“made it harder to buy digital music from Japan”* (E-P206). The capability lost here was being able to easily get hold of Japanese music. E-P206 noted that it would still be possible to get the music from Amazon or iTunes using Japanese accounts, but that it’d be too onerous to do so. It was also the case that participants did not necessarily make full use of the all functionality provided by a service. They were aware that they were losing access to this particular functionality, but, as non-users, were not concerned: *“Not really. The other services that I’ve been affected by having tended to be things that were nice to have but not necessarily things that I was dependent on.”* (E-P81).

Much of the lost capability came from a kind of incommensurability of services, especially in terms of what we previously described as the ‘patina’ associated with a service; metadata, usage histories, other interactions. E-P6 lost their photo ‘timeline’ and couldn’t replicate it in a new service *“as it would just upload them to the end of the stream, and tell everyone they were taken today.”* Exporting a set of RSS feeds was straightforward, but organisation was lost because *“not all of them were still active or still fit the same categories”* (E-P62). Things like indicators of progress through content were also impossible to replace once lost: *“I was sad to have lost some radio programmes and quite cross that I had to search for my progress through some series, and also that I had lost some recipes.”* (E-P287).

E-P306 found that replacement services were *“unstable, expensive, or not advanced enough”*, and that in the absence of a replacement, it was their own level of expertise that meant they lost the capabilities provided by the closed service: *“In the end I decided to try programming to achieve similar results - I was only half successful. I’m not the best programmer in the world.”* (E-P306). The match between a tool’s capabilities and a participant’s own skills and use cases was also a problem for E-P81, who found that Google’s *“Translator Toolkit occupied a good space in between the standard Google Translate and professional/paid tools so its closure has had a fairly significant practical impact on me.”* Losing a tool that was a good match for them meant that, even though it was still possible to conduct translation activities, they saw it as *“a bigger chore and [so they] don’t always volunteer to do so to the same extent”*.

5.2.4 Trust. Closure compromised participants’ trust in other services that were outside their control: *“I was very nervous to trust another app, in case that one then also went down the same route.”* (E-P6). It left participants feeling upset that they’d put their faith in an externally-controlled application: *“I felt irritated and dumb. I was irritated because my primary Web interaction was interrupted, and I felt dumb because I did not realise how dependant I had become on that Google product”* (E-P181). E-P186 made use of OpenDiary for logging personal notes for more than a decade before it closed. The service eventually reopened, but E-P186 *“wouldn’t go back to open diary - partly due to convenience, and perhaps because I lost trust in them.”* These participant observations point to a general sense of faith in the continuity of a service: E-P186 noted that they *“never really thought of the platform as something which might just not exist some day”*. The closure of a service left them questioning that faith in the permanence of other arrangements. When people had used a service

for a long time for highly personal data, the thought of having to work out which service could next be trusted was daunting: “[I] would have to start again in terms of trusting another company that handles money” (E-P287).

We also observed trust surfacing in a more specific way, rather than just a general loss of trust in hosted services. Several participants were concerned about whether a service that was closing would ensure the proper disposal of their data. Closing services should “provide certainty around data safely etc” (S-P240) and “shut down safely and securely” (E-P297). Participants were perhaps suspicious that their data might not disappear, but that it instead might be passed on to others: “Where that data is held? Is it secure? Can I access it and retrieve it? Who else can access it?” (S-P304). S-P104 wanted to have “[a]ssurance that all data has been destroyed and not sold on to a 3rd party.”

5.2.5 Time and effort. Managing digital possessions is laborious, requiring time and effort to maintain possessions in good order. Participants’ responses demonstrated a recognition of the significant possession work entailed in ensuring that they would not lose contributions or be left without functionality when a service closed. The time and effort demanded to migrate data across (often incompatible) services can put people off even trying: “The time and effort penalty of migrating data might mean that I didn’t bother with migrating old data and would probably start afresh.” (S-P8).

Identifying alternative services is time-consuming: “Mildly annoyed that I need to spend time researching other sources” (S-P104). Search efforts do not always yield a successful alternative: “I both searched for similar services and posted on forums asking for suggestions. The main reasons for giving up were cost and/or complexity” (E-P81). Some participants successfully identified alternatives, but the effort required to use them meant that they eventually gave up: “The shutdown meant trying to keep track of 30+ online news sources individually” (E-P59), “Everything required creating Japanese accounts for Amazon or iTunes and I didn’t want to” (E-P206).

Finding a good (or better) alternative doesn’t preclude additional time and effort being required. E-P181 was pleased with the self-hosted replacement that they found for Google Reader because “the experience was pretty good, as good as or even better”, but they eventually gave up on the alternative “because of personal life (no time to maintain the server)”. Simply knowing about an acceptable alternative is no guarantee that people will be able to successfully maintain a switch over the long term.

The closure of services could also mean the closure of communication channels. E-P243 had an online-managed energy service close, forcing them to another medium to try to get their transaction history: “Very frustrated at the lack of online support relating to my old account. Resulted in a number of telephone calls trying to establish what was happening.” In this way, costs associated with the orderly and accessible closure of a service are transferred onto users.

5.2.6 Notice periods. The final theme we identified is a narrow one, but came up over and over in participants’ responses: notice periods. Some participants had been happy with the notice they’d received because the provider “flagged it way in advance of actually closing” (E-P65). But sometimes the closure was abrupt: “the organization closing the service was operating in a very grey area that turned out to be completely illegal, forcing their immediate closure” (E-P75). Participants also made general suggestions about “giving people a warning that these services are shutting down allowing time for people to access any items they may wish to save” (S-P259) and suggesting that “users should be informed in advance to make the most adequate preparation” (S-P47).

The complexity or difficulty associated with migrating away from a service was something that participants thought should be accounted for in the length of the notice period. E-P32 suggested that the length of the notice should depend “entirely on the type of service. A cloud storage service should let its users know well in advance of the shutdown date, should give instructions on how they

should access and migrate their data.” This sentiment was echoed by E-P59 who suggested that the “[n]otice period should be increased in proportion to the difficulty of moving away from the service.” The need for time was not just limited to the logistics of getting data or finding alternatives. Notices of closure should also be served “*in advance, so that users are psychologically prepared*” (E-P195).

5.3 Idiosyncratic insights

While the themes we generated provide a reasonably representative account of the data collected, there were individual comments from participants that were idiosyncratic; they did not fit a particular theme. These comments are not generally representative of the sample, but they do give specific insights into challenges associated with service closure that we felt merited reporting.

One participant reported experiencing service closure as a cascading event: “*Inability to access other services which were registered under a Demon email address.*” (E-P33). For this participant, their email address acted as a gateway to authenticate with other services. When they lost access to their email address, it meant that access to other services shut. Those other services may have remained open, but the denial of service stemming from the email closure effectively closed off access to these services, too.

E-P65 provided some specific detail on the way that the ‘This is My Jam’ service closed: “*They did a really good job of closing it down respectfully, offering a download of my archive, and preserving an archival version of the site online.*” Despite closing in 2015, the ‘This is My Jam’ archive is still available¹². This seemed unusual amongst participants’ experiences, in that an archive was still accessible beyond the closure of the service.

Related to participants’ perspectives on post-closure data management in the Trust theme, E-P186 reported that when the OpenDiary service they use closed, they “*lost access to all my entries. But weirdly, the platform was relaunched a few years later and I was given access to them again.*” This did provide one concrete answer to the question ‘what happens to my data when a service closes?’: that it gets resurrected some number of years down the line as part of a successor service.

6 DISCUSSION

Our empirical data reveals both the emotional and practical impacts of the closure of digital services. Sometimes the closure of services leaves people feeling disempowered. Sometimes it creates lots of new time- and effort-consuming possession work for people.

In this Discussion, we summarize the data our participants provided and attempt to contextualize it among the broader factors that act on the way that services run and close. We build on these contextualized findings to develop proposals for service design that could help to ameliorate the worst of the negative practical and emotional effects of closure on users. Our proposals are informed by the data but are necessarily speculative too: further work would be needed to develop ‘off the shelf’ protocols that designers could use to develop service closure patterns.

6.1 Facilitating return of data

Getting content back that had been put into a service was clearly participants’ main priority. Some participants reported receiving data conforming to open standards, but they also suggested that the hassle of migrating data would be too great and that they’d just start again from scratch. Making data easier and more portable is challenging from an ontological perspective – services are not completely fungible and have unique features. This might make the export from a given service impossible to represent within the constraints of another. That does not mean that there can be no common ground, but it does mean that certain facets of a user’s data will be lost.

¹²<https://www.thisismyjam.com/>

When ranking the importance of different factors in service closure, participants did not rate the need to get access to metadata very highly. However, losing this kind of data (e.g., episode progress) was mentioned by several participants in their comments. We have described this data as a ‘patina’ that is built up over time through interactions with a service. This further compounds the incommensurability problem because this patina could include learning models that are based on the specific ontology of a service. This makes exporting things like a recommendation system built on playback history very difficult.

Services have economic reasons for making it difficult to access data in a structured format, which creates tension with other uses [54]. Lock-in, which makes it difficult to change services and reduces customer turnover, is undoubtedly part of the design of services [48]. Contemporary data regulations like GDPR have provision for Subject Data Requests; companies have a legal obligation to make data they hold on a user available to that user. But fulfilling obligations under data regulations is not the same as meeting users’ actual needs with regard to understanding and controlling their data. (This disconnect is obvious in the way that web cookie notices are presented [33, 64].)

For an example of the gap between meeting regulations and providing something useful to an average user, consider Flickr, the online photo-sharing service. Figure 2 shows the results of making a data request for one of the authors’ data (a combination of 27,000 photos and videos). Three zip files comprise the metadata held and take the form of a JSON file for every image or video detailing sharing preferences, album membership and other data about the artefacts that have been uploaded to the service. The photos and videos themselves are spread across 56 zip files. There is no simple, user-friendly way to download all of these files in one go; a user must click each link. The zip files containing the uploaded photos and videos comprise individual files. They are effectively unstructured; they are not sorted into directories representing albums, for instance. As such, once all zip files are downloaded, a user is left with many directories containing hundreds or thousands of unsorted image and video files.

For developers or very technically capable users, the exported Flickr data provides enough for tools to build some kind of organisation out of the unsorted artefacts. For an average user, though, this output is likely to be very difficult to make use of without expending a huge amount of effort to reclassify files by hand. In this context, it is not surprising that people are concerned about losing data, but also feel that they may have to give up on trying to recover it.

Proposal: What can be done about the export of data to increase the value to end users, rather than just meeting a minimum of regulatory demands? In terms of the data that is exported, a more user-centred rather than regulation-centred approach to the design of export tools might produce outputs that are useful to (and usable by) an average user. Just as Blevis suggested that the disposal of digital hardware should be part of the design process [5], the way that users export their own data should be part of the design of services too. Useful and accessible outputs for users might come into conflict with a service’s desire to keep users locked-in. A simple solution would be to make ‘advanced’, up-to-date data export options available once the decision to close had been taken. This could be packaged into, for instance, an HTML bundle for offline viewing that would be more accessible to most users than the dump of unorganized data that many services produce.

Several participants – most likely contributors from the */r/selfhosted* community on reddit – suggested that opening sourcing a closed service could enable individuals or other companies to take over hosting of a service. This is an especially salient issue for service-dependent IoT devices, which become inoperable when the service-controlled API is shut down (with the only solution being to reverse engineer it [40]). This would eliminate any commensurability issues with data (including any patina data built up during service use), but with intellectual property issues and

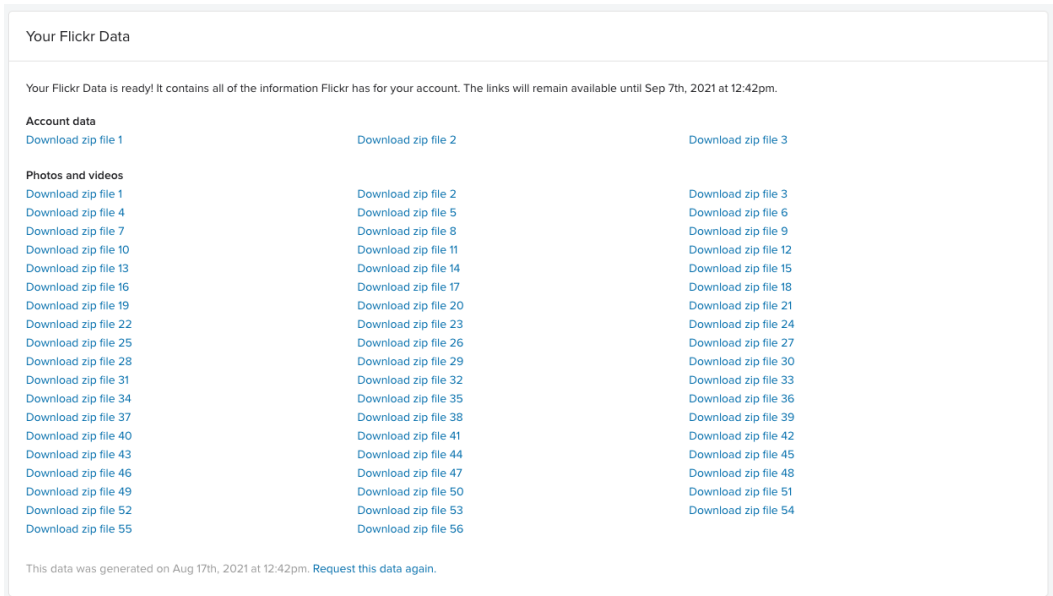


Fig. 2. The result of requesting a data export from Flickr, a popular image-sharing service.

without a strong incentive (e.g., a regulatory requirement) it is not a realistic solution. Third party tools for processing exported data¹³ are a more plausible route for users to be able to re-create aspects of the service, but self-hosting is likely to be beyond the capability of most users.

We have suggested that service patinas could be important. We asked participants to rank the importance of different aspects of service closure (see Table 2). Primary artefacts, like photos or videos, were the most important things, while other aspects of service patina, like metadata from use over time, were seen as less critical. As we required participants to perform a forced rank, we don't know if the ranks meant that these patina-related characteristics were *unimportant* or just *less important*. We think that the concept of service patinas that we have developed here is a novel and important one, and that empirical work to better understand what the concept might mean to users and how it manifests in existing systems.

6.2 Designing for the end of service life

We saw in our data that participants were keen to have plenty of notice before the closure of a service. This was made clear both by the rank they assigned to having a long notice period, but also in the comments that they made. It makes sense that participants see this factor as important because it provides a window in which to wind-down their use of a service (thereby ending its critical role in daily routines), find alternatives and retrieve any personal data. In this sense, a long time frame is a kind of *enabling factor* for other activities related to the closure of a service.

Offering long closure periods runs counter to the economics of service closure; services are typically (though not always) being closed because their continued operation is not economical for the controlling organization. Giving users plenty of time to leave means running a service that is losing money for longer. For larger businesses running multiple services, there should be a retained interest in the careful winding-down of services; we saw how badly-handled closures

¹³e.g., <https://github.com/nickivanov/flickr-meta-export>

affected participants' trust in and opinions of the companies responsible. Giving a long notice period is important, but so is effective communication of changes and their impacts on users. Some participants felt they might have missed information about closures amongst a variety of other messages from a service provider.

Proposal: One option to ease the financial burden of continued service operation might be a staggered freeze of functionality in a service. Over time, parts of the service could be moved to a read-only state. This could give users a long period of time to migrate away from the service (e.g., collecting data), an incentive to make the change as the service lost functionality (because things stop working), and reduce costs for the service owner (e.g., predictable resource requirements, no ongoing development costs).

Personalized messaging could help improve the quality of communication to users. After all, the patina users collect through use is controlled by the service owner; what a user has stored, what functionality they use and how often they use it is known to the service. Communications could incorporate this information to help users better understand which functionality they are making use of and how significant (based on frequency and volume of use) the change is likely to be for them.

6.3 Appreciating non-transactional aspects of closure

We found a range of negative emotions (sadness, frustration, anger) were associated with the closure of services. It is not all that surprising that people did not have positive feelings about a service closing while they were using it, but these responses were not just about feeling annoyed that the services had closed.

Ultimately, the closure of a service that is not controlled by a user is intrinsically disempowering, whether it is an online music discovery platform or the only bank branch in a village [37]. But participants' emotional responses were not just to having something they relied on being taken away by another actor. They were sad about the personal diaries that they'd lost. They felt frustrated that they'd allowed themselves to become dependent on something they had no control over. They felt that their data had been held ransom by a successor company.

The loss of a service left our participants feeling disconnected from others. Sometimes the closed service facilitated direct communication, but sometimes the disconnection came from tools providing presence (e.g., photo-sharing) or discovery (e.g., of new music). Even though these services did not necessarily facilitate direct message passing, their loss still left a feeling of disconnection. This highlights the need for service owners to be cognisant of how their services are appropriated in practice. Just as a local bank branch may facilitate very much more than withdrawals and deposits, so digital services may provide social layers beyond what their designers envisaged.

Proposal: There are obvious ways to minimize negative feelings associated with the closure of services. A well advertised and competently managed closure combined with the effective and usable export of individual data would perhaps have ameliorated some of the negative feelings participants had. Supporting transition to other services with, for instance, guides to help users migrate to other services would've helped people to adjust. These kinds of practical, user-centred components of service closure could also help to reduce the time and effort expenditure that closing services demanded from users (and which led to frustration and annoyance).

Beyond this, though, services could explore creating a permanent archive or 'memorial' for the service, as one of our participants described it. Memorialization has been an important aspect of thanatosensitive research [50, 52], with consideration being given to how, say, Facebook pages of deceased users could be memorialized. Perhaps the idea of a memorialization and the change of function that it entails could be applied to the closure of a service. Access to a frozen archive

of content might help to minimize participants' fears of losing content. 'This is My Jam' has had this kind of archive up and running in the six years since the service closed. Some kind of 'best of' memorialization for a service, explaining the history of the service, and perhaps some of the most effective features of the service, might, in the long term, become a way of facilitating more positive feelings (e.g., nostalgia) about the service. Maintaining this kind of presence would seem to be particularly important in instances where there is a possibility of a service re-opening (as, for example, OpenDiary did).

6.4 Speculations on service closure in the workplace context

Our paper has considered service closure as a general phenomenon. Participants largely responded to our questions in a personal capacity; reflections on artefacts and services focused on this kind of private use (and the private losses that come with closure). There was little in responses that related to work and the effect of service closures on it. Given the paucity of data, we are reluctant to make strong assertions about how issues of service closure might affect workplaces.

We can speculate about the effects of closure. Workplace text chat platforms, for instance, are a valuable for institutional memory [24] but have also become important for workflows – like deploying code [39]. The interconnectedness of the tools that workers use can help them get more done; Fitzpatrick et al. [23] found that communication functionality being built into source-control tools helps workers contextualize team activity. The affordances of different tools during collaborative work influence how tools are appropriated into practice (and this has been an important part of CSCW research [10]). There has been less focus on what happens when, for whatever reason, services that were available in a workplace are taken away.

Thinking about the effects of service closure on collaborative work seems important, given the increasing reliance on services hosted by third parties, with cross-service integration creating ever more complex service patinas. If tools are a host for institutional memory, how is work affected when a component of a complex network of tools closes? The temporal and spatial context provided by patinas built through the work of collaborating colleagues is a powerful tool [17], but what happens to the chats, reactions, build logs, call histories and calendars that might rely on a particular service?

There are differences between personal and workplace contexts. Organizations are more likely to have systems with bespoke components. They may have the resources (human and capital) to navigate service closure by building tools to enable service patinas to be carried over. Perhaps workers have a different perspective on services closing down if they were not responsible for choosing them in the first place.

Understanding the particular nuances of service closure in workplace contexts, including how patinas form across the surface of collaborative workplace tools, is beyond the scope of this paper and the data we have collected. However, the considerations we have enumerated in this discussion would, we speculate, still be relevant to a workplace context. *Facilitating the return of data* is critical in workplace settings. Not only might data be critical to ongoing collaborative work (e.g., activity logs from earlier stages of a project), but there may be regulatory requirements that mean that data must be held for extended periods. One area that workplaces might have an advantage over private individuals is that they may have more leverage in the purchasing of services; this might give them the power to ensure that the return of data is properly facilitated. Likewise, larger organizations may have significant power when service operators are *designing for the end of service life*, where they may have the resources to implement technical and process solutions to cope with the loss of a service. *Appreciating non-transactional aspects of closure* is also important where services have supported collaborative work. A service closing might also represent the disbanding of a team,

with attendant emotional effects. People's feeling of competence may be bound to particular tools too, so changes to them might materially influence how people feel about their work [1].

Our suppositions have been about workplaces with a more corporate flavour of service provision. In less constrained contexts, workers may be creating their own assemblages of services [44]. In these contexts, we might expect the effects on collaborative work to be similar to the personal experiences we have focused on in this paper; where people have produced their own assemblages of services, they are likely to have less control over the connections between them.

As we have noted, these are *speculations* about how service closure might look in the context of collaborative work. It is difficult to draw firm conclusions, but we know that for collaborative work, the contextualization of work artefacts is critical. Context is often recorded in the kinds of metadata that constitute a service patina. Understanding how these patinas develop and the challenges their loss cause for collaborative work should be the subject of further empirical investigation.

6.5 Limitations and future work

We have presented an initial exploratory study of people's experiences of digital service closure. The nature of the study means that the data we have obtained does not allow us to form specific protocols for service closure that would minimize negative effects on their users. To generate protocols for dealing with particular scenarios, future empirical work should be more constrained and focused on eliciting participant evaluations of particular scenarios and protocols for closure. A participatory design approach could be used to develop plausible 'good' protocols for evaluation. Increasing the level of specificity in this way would help to generate more precise insight into how people use services and their expectations for their withdrawal.

In this work, we have focused on the closure of services by their operators and subsequent effects on users. However, there may be some overlaps with non-use [2, 25, 34, 43, 67]. In some non-use scenarios, users fall out of the habit of using a service, or never get into the habit of using them [35]. Service closure probably has more overlap with scenarios where non-use is a product of financial or moral objections to the ongoing use of a service (e.g., the service has hiked prices or changed a policy regarding the processing of personal data). By testing the intersection between non-use and service closure, future work might be able to strengthen accounts of people's relations with the services that they rely on.

Our contention is that, eventually, all of our participants will experience the closure of one of the digital services that they use. To this end, we solicited the experiences of both participants who had experienced closure and the speculations of those who had yet to. Our analysis showed that there was a good overlap between what people experienced and what people *expected* to experience. To build on this exploratory research, it would make sense to conduct investigations with more finely partitioned samples. For instance, several participants commented on the closure of Google Reader. Focusing on these participants could yield a detailed case study that might inform a more specific set of recommendations. In the same vein, a study that separately samples participants who have yet to experience closure might allow for more the use of more specific elicitation tools to get a clearer impression of the relationship between people's fears about service closure and the reality.

7 CONCLUSION

Digital services are deeply incorporated into people's lives. Closure is the inevitable destination of many services. Given their importance to people, how they cope with their disappearance is an important topic that we know little about. In this paper, we have presented an initial exploration of the phenomenon. We used a questionnaire and qualitative analyses to understand the emotional and practical effects service closure has on people. We found that interoperability difficulties made data recovery challenging, that finding and setting up alternative services is onerous, and that the

closure of services can have lasting emotional impacts on people's perspectives on digital services. We attempt to balance participants' experiences and perspectives with the broader context in which services are closed to make a number of suggestions for good practice in service closure. This contributes a new facet to our understanding of how people interact with their digital possessions and memories that has practical relevance to the way services are designed, built and maintained.

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