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Escaping unsustainable digital interactions: Toward "more meaningful" and "moderate" online experiences

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ABSTRACT

Growing and even excessive use of digital technology has unquestionably fuelled demand for digital devices and online services leading to a wide range of societal and environmental impacts. In sustainability terms, ICT as a whole is estimated to produce up to nearly 4% of global greenhouse gas emissions. As presumed responsible innovators, the HCI community should now consider design strategies that will reduce use and demand for digital technology for the good of both its users and the planet—strategies perhaps even seen as retrogressive in an era where digital technology is constantly implicated in innovation and economic growth. Prior work has noted the potential to design "more moderate" interactions for sustainability, simultaneously addressing negative societal impacts on users' wellbeing, relationships, productivity at work, and privacy. In this paper, we explore how we may design intentionally moderate digital interactions that retain our participants' "more meaningful" experiences. We report on the outcomes of two design workshops to uncover experiences of meaningful device and service use, to inform practical designs for 'moderate and meaningful' interaction. From this, we offer design recommendations that aim to address the multiple negative impacts that digital technology can create, and discuss the possible barriers to these designs.

1. Introduction

The negative environmental impacts associated with digital technology have long been known (cf. Blevis, 2007), including those linked to the energy consumption of the underlying internet infrastructure, data centres and communication networks. To put this into context, according to key carbon accounting experts (Andrae and Edler, 2015; Belkhir and Elmeligi, 2018; Malmodin and Lundn, 2018), the Information Communication Technology (ICT) sector has been found to contribute between 1.8–2.8% of global greenhouse gas emissions, with estimates inclusive of the full supply chain emissions suggesting this share could actually be as much as 2.1–3.9% (Freitag et al., 2021). Whilst there have and continue to be clear gains in energy efficiency especially in data centres, these are regarded as being outstripped by the growing demand for online services (Preist et al., 2016). Thus, efforts are required to alleviate this constant *data demand* i.e. the "*demand for network connectivity and online services*" (Lord et al., 2015, p. 2729).

To date, there have been several calls for HCI designers and practitioners to become more aware of digital devices and online services' environmental impacts for the services they create, and develop interaction designs that promote the sustainable use of these technologies (Blevis et al., 2017). These designs include: the removal of so called 'digital waste' (Preist et al., 2016, p. 1330), i.e. data that is not *usefully consumed*, such as when users play a video simply in order to listen to its audio (Lord et al., 2015; Preist et al., 2019); and the support for fewer, "more meaningful" video streaming experiences for households (Widdicks et al., 2019). Such designs, which aim to encourage *fewer* user interactions with digital devices and online services—or at least promote interactions that are less data intensive per interaction—can even be thought of as retrogressive given the abundance of positive impacts that digital interactions are purported to create in peoples' lives.

Despite the possible benefits, there is an increasing awareness of negative impacts that can be introduced by too much engagement with digital technology (e.g. digital addiction (Whillans, 2019) or threats to online privacy (Cadwalladr and Graham-Harrison, 2018))—leading to a body of work seeking to understand and mitigate these (Section 2.1), and even unprecedented policy action such as the limit recently imposed on childrens' online gaming in China (Ni, 2021). Prior work in

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sustainable HCI has highlighted that there is potential to design more "*moderate*" interactions that reimagine these technologies to reduce data demand (and thus energy and infrastructure growth), whilst simultaneously avoiding the potentially negative societal impacts that users can experience on their wellbeing, productivity, relationships and privacy (Widdicks and Pargman, 2019).

Contributing to this work, we similarly advocate for 'better', more positive (Calvo and Peters, 2014) or "*more appropriate computation*" (Dix, 2017, p. 131)—specifically aiming to investigate how we can use HCI design to promote more moderate and thus lower data demanding interactions, without moderating the digital experiences that are considered the most 'meaningful'. Explicitly through reducing data demand and alleviating pressures on the underlying internet infrastructure, we respond to notions of unlimited growth, such as Preist et al. (2016)'s *"Cornucopian Paradigm"*, in a way which also improves social sustainability in terms of the connections made by Widdicks and Pargman (2019). Central to this, we do not draw a distinction of what is meaningful (cf. Mekler and Hornbæk, 2019) or seek for universal designs, rather we allow our participants to personally interpret what digital interactions *are meaningful to them* and offer design opportunities that can be uniquely tailored to their needs.

We study this phenomenon by analysing data from two UK-based workshops with a total of 13 adult participants and regular internet users living in the North of England. Through these workshops, we aimed to: uncover what online interactions participants viewed as meaningful and what (other) interactions could be moderated; and generatively explore design ideas *with users* to identify ways to moderate service use, and thus lower energy impacts—without compromising their meaningful digital experiences. From this, we offer several concrete design recommendations including "internet speed bumps", "interaction flows", "metadata layers", "layers of service"—all aiming to address multiple negative impacts that technology can create on people and the environment. We also discuss the challenges our design proposals raise given the first world economic context of these services and our study, noting that some of our design implications cannot be introduced without policy intervention.

2. Background and related work

Digital devices and online services have unquestionably become deeply ingrained in the lives of many people worldwide, leading to an emerging and unexpected range of societal and environmental side effects. These effects can be both positive and negative. Technology has been cited as being important in facilitating closeness or aiding relationships at a distance (Chai et al., 2017; Chien et al., 2016; Yang et al., 2017). For example, internet-based remote collaboration has very clearly enabled some to find new ways to work during the COVID-19 global pandemic. Even here however, this benefit has brought fresh concerns regarding excessive screen time and constant availability to work colleagues (Alaqra and Kitkowska, 2021) and the emergence of new digital inclusion and participation issues. Many of these issues are of course not new to HCI, where the more negative effects of devices and services have already been a subject of a considerable body of research.

2.1. HCI and the negative impacts of devices and services on users

Digital devices and online services can complicate workers' lives, with constant connectivity leading to employees' time and availability being used as an economic service (Mazmanian and Erickson, 2014); anxieties of device and service use can negatively affect productivity (Wang and Suh, 2018); and email can cause stress (Blank et al., 2020; Kushlev and Dunn, 2015; Mark et al., 2016; 2012) as it "*speeds up the pace of work*" (Mark et al., 2012, p. 562).

To address this and help employees switch off from work at home, Cecchinato et al. identify "*micro-boundaries*"—strategies users adopt for their email, e.g., checking work and personal email on separate clients (Cecchinato et al., 2015, p. 3996). Users have also begun to take-up productivity tools to improve their task focus (Kim et al., 2016; Mark et al., 2018), benefiting those who feel least able to control their online distractions (Mark et al., 2018). Broadening out beyond work, Kim et al. highlight that productivity tools need to combine manual and automated logging techniques to "*capture comprehensive and personally meaningful tasks*" (Kim et al., 2019b, p. 10). In this notion, Guillou et al. offer self-reflections of 'time well spent' to analyse both productivity and wellbeing at work (Guillou et al., 2020).

Alongside impacts on work productivity, the growing presence of digital technology has led to people expecting more from technology than of each other (Turkle, 2017). These observations have prompted exploration of how device use impacts relationships, e.g. between parents and children (Ghosh et al., 2018; Hiniker et al., 2016; Kildare and Middlemiss, 2017; Mazmanian and Lanette, 2017) or couples (Lapierre and Lewis, 2016). Oduor et al. uncovered that smartphones can create moments of "*desirable disengagement*" for family members to have some alone time—yet, non-urgent device use in the presence of others has also been observed to make family members or couples feel "*socially disconnected*" or frustrated (Oduor et al., 2016, pp. 5-6). Similarly, Moser et al. found that perceived importance of activity and the time taken for it highlights whether using a smartphone at the dinner table is appropriate (Moser et al., 2016); and Kildare and Middlemiss outline how parents' use of technology can make them seem "*emotionally unavailable*" to their children (Kildare and Middlemiss, 2017, p. 591). Tools exist to limit children's access to devices, but they have been found to not always be utilised as they do not take into account the complexities and dynamics of everyday life (Mazmanian and Lanette, 2017).

Online threats to user privacy have been extensively studied. This has included understanding different users' perceptions of, and behaviours towards, their online privacy (Emami-Naeini et al., 2019; Fruchter and Liccardi, 2018; Gambino et al., 2016; Kumar et al., 2017; McReynolds et al., 2017; Ray et al., 2019; Sundar et al., 2019), as well as the strategies they employ to protect it (Machuletz et al., 2018; Sannon et al., 2018). Designs to promote privacy and security have ventured into the classroom (Kumar et al., 2019), gamified cybersecurity (Chen et al., 2019), and outlined the roles of different stakeholders (including HCI design researchers, privacy practitioners and policy makers) for 'privacy by design' (Wong and Mulligan, 2019). Highlighting the difficulty of designing visible security mechanisms, Distler et al. discuss that, to create positive user experience, the transparency of security designs should be "*provided in a meaningful and purposeful way that is aligned with users' goals*" (Distler et al., 2019, p. 10).

Recent work has focused on promoting digital and psychological wellbeing (Calvo and Peters, 2019; Cecchinato et al., 2019). This follows concerns surrounding the effect of technology design on users' attention spans (Kushlev et al., 2016), overuse of devices or services (Ding et al., 2016; Gui and Büchi, 2019) and the wellbeing impacts on different user groups (Hill et al., 2015; Nansen et al., 2012). Design suggestions have included promoting mindfulness (Zhu et al., 2017); enabling self-tracking (Ayobi et al., 2017); viewing "*wellbeing-as-interaction*" rather than a goal (Rodgers et al., 2019, p. 1); reducing time spent on applications (Kovacs et al., 2018; Okeke et al., 2016); enhancing self-control (Lyngs et al., 2019); and evaluating tools for digital wellbeing and self-control (Lyngs et al., 2020; Monge Roffarello and De Russis, 2019; 2021). Focusing primarily on self-tracking, Monge Roffarello and De Russis (2019) found that users tend to like wellbeing tools, but critically highlight that these tools are not restrictive enough to change behaviours that users perceive 'addictive'. Yet designing the right level of engagement is difficult: Lyngs et al. (2018) highlight the complexities in designing for what users want and what they "really" want, and suggest that future work should give users the choice of how a system will infer their preferences.

2.2. Towards moderate device and service use

Sustainable HCI (SHCI) addresses the growing environmental impacts arising from the use of internet-connected digital devices (Blevis, 2007). Within this work, Preist et al. (2016) highlights the unsustainable growth cycle of the internet infrastructure: whereby new infrastructure is needed to cater for increasing numbers of internet-connected devices and services, in turn driving data-intensive innovations that drive further demand and infrastructure growth. Interaction designers are encouraged to create products that are "more conscious" of their requirement for and externality of data, digital services and their environmental footprint (Preist et al., 2016). For example, a relatively small usability change to a popular service (i.e. removing unnecessary video from YouTube music where it is being used for listening only) has been cited as having a comparable emission reduction to running a data centre entirely on renewable energy (Preist et al., 2019). Researchers have also been investigating users' digital device and online service use to understand the impact of mobile devices on the demand for data (Lord et al., 2015; Morley et al., 2018; Widdicks et al., 2017); how similar digital activities in the home have varying energy impacts (Bates et al., 2014); and opportunities to reduce video streaming, the largest contributor to internet traffic (Widdicks et al., 2019).

Hilty points to the need to avoid the unexpected trap that efficiency gains in computing can lead to additional growth in demand (a noted 'rebound effect' known as Jevons paradox): we must create a condition of "sufficiency", a ceiling at which capacity is reached and exponential growth stops (Hilty, 2015). This should create *sufficient* levels of digital device and online service use—otherwise, it is clear that the growth in demand will continue unchecked (Preist et al., 2016). To break this growth cycle, Widdicks and Pargman (2019) highlight the need to move towards moderate (i.e. reduced) internet-connectivity and outline how the negative societal impacts of devices and services (described above) can be utilised to drive this agenda. For example, by moderating internet connectivity in users' working lives, they may become more productive in their work tasks whilst simultaneously reducing internet related demand and externality (Widdicks and Pargman, 2019). This direction of work takes an approach which is user-focused (rather than sustainability-focused like prior work (Lord et al., 2015; Widdicks et al., 2017; 2019)) and follows calls for a more positive framing of designs aiming to address sustainability concerns (Mann et al., 2018)—transitioning the issue of internet demand to focus on the "*mores*" it can bring, rather than what it takes away (Gui and Nardi, 2015).

While more moderate use of devices and services might align with an environmental sustainability agenda, moderation has already been called for in HCI to combat other of technology's negative impacts: "Digital detoxes" exist for taking breaks from digital media consumption (Syvertsen and Enli, 2019)—perhaps due to the time lost to "*datafication and automation enabled and reinforced by mass-mediated forms of networked connectivity*" (Hesselberth, 2018, p. 2007). This explicit 'non-use' (Satchell and Dourish, 2009) has been previously reported, as users take breaks from their social media (Schoenebeck, 2014), "unplug" from online communication (Thomas et al., 2016), and limit their Facebook use (Baumer et al., 2013). In the latter, Baumer et al. found that users limit their Facebook use for concerns of privacy, data misuse, banality, productivity, addiction and other pressures (Baumer et al., 2013). Several apps are available which specifically block access to services to help users maintain concentration, e.g. StayFocusd (2019), Turkey (2019), and Forest (2019).

2.3. Towards meaningful device and service use

"Meaning" and "meaningful use" have both previously featured in the HCI discourse: the use of "Slow Design" for creating mindful and meaningful interactions that foster product attachment (Grosse-Hering et al., 2013); improving radiologists' wellbeing at work (Laschke et al., 2020); and, ensuring devices add value to our lives through "*designing for meaningfulness*" (Carpenter and Overholt, 2017, p. 96). Hassenzahl et al. suggest designing meaningful and positive experiences from the perspective of happiness rather than efficiency of output, providing the example of meaning through watching a TV programme: "*It is not primarily about, for example,* [TV programme] *in high definition, with stereo surround, but about watching the* [TV programme] *in a meaningful, satisfying way*" (e.g. together with family) (Hassenzahl et al., 2013, p. 29). Researchers have also suggested prioritisation of "*eudaimonic*" interaction experiences, as they are associated with ideas of fulfillment, long-term importance and meaningfulness (Mekler and Hornbæk, 2016). Even tech-giant Facebook pledged in 2018 to better encourage "*meaningful interactions between people*" (Zuckerberg, 2018).

Most recently, Lukoff et al. (2018) explored meaningful smartphone interactions, finding that the same app can provide different meaningful experiences based on the type of use: e.g. Facebook users associated meaningless experiences with scrolling passively through the app, rather than the ability to engage with their friends. They outline design recommendations for meaningful interactions including hiding cues that trigger habits, or designing for positive disengagement (Lukoff et al., 2018). As the HCI community has begun to design for meaning, we position that we can further explore users' meaningful digital experiences (beyond focusing on smartphones (Lukoff et al., 2018)) to uncover how we can create more moderate uses of devices and services without moderating meaningful interactions.

Responding to concerns that HCI needs to be theoretically grounded (Kaptelinin, 2018) and potentially simplify designing meaningful interactions, Mekler and Hornbæk (2019) use psychology literature to create a framework of meaning with five components: connectedness (i.e. the links to "*aspects of the self and the world we are in*" [p. 4]); purpose (i.e. "*having a sense of direction*" [p. 4] or goals to meet); coherence (i.e. "*the extent to which one's experiences make sense*" [p. 5]; resonance (i.e. something immediately making sense without the need for reflections or explanations); and significance (i.e. "*the sense that our experiences and actions at a given moment feel important and worthwhile, yet also consequential and enduring*") (Mekler and Hornbæk, 2019, p. 6). They emphasise that it is difficult to empirically understand what interactions users experience as meaningful, and suggest that researchers in this area focus on measures from their framework "*that account for different components of meaning*" (Mekler and Hornbæk, 2019, p. 10). In this paper, our use of the terms 'meaning', 'meaningful', or 'meaningless' link to the specific framework components 'purpose' and 'significance'. However, we explicitly enable our participants to define and determine what they interpret as personally meaningful within digital interactions and look to suggest moderate design implications that can be tailored based on what a user deems personally meaningful or not.

This research landscape illustrates the many different ways that technology impacts peoples' lives, and the need for the design of technology to afford more meaningful interactions in moderation: both for the endemic benefits to mitigate possible harms to the user, but also to drive down the energy and environmental demands. In our study, we explore from a user's perspective how devices and services can be designed that achieve these goals.

3. Method and participants

To arrive at technology designs to promote more personally meaningful device and service uses with less data (more moderate) data impact, we conducted two co-creation workshops in March 2019. We sought to answer specific questions: How do we better support this 'moderate use' of devices and services for social *and* environmental concerns? How do we ensure that our designs aim to moderate use in ways that users actually want? What do users find meaningful and how do we ensure this meaningful use is *not* moderated?

These workshops: 1) gauged a wider understanding of users' experiences of digital device and online service interaction; and 2) used co-creation methods to involve users in the design process for this early

stage of ideation (e.g. Sanders and Stappers, 2008). The workshops were ethically approved by the Faculty of Science and Technology Ethics Committee at Lancaster University.

3.1. The design workshop

We recruited our participants via email; physical flyers on our University campus and in the local town; and using snowballing methods. We recruited a total of 13 participants, and offered a choice of two workshops to more conveniently match the schedules of our University and town demographic groups. 6 participants attended the first workshop, and 7 the second; members of the research team also attended the workshops as facilitators (2 at the first, 4 at the second). We offered a £10 voucher for participation. Workshops were conducted at a university campus location and with a duration of 3 hours each. The workshops were audio-recorded for later transcription and analysis.

The workshops followed identical schedules:

1. *Introduction and ice-breaker.* The term 'internet use' was explained by the researchers and participants were encouraged to think broadly of both their good and bad perceptions of internet use. The ice-breaker required participants to provide their name, occupation and regular internet activities, helping frame each participant's internet use (outlined in Table 1).
2. *Individual post-it note exercise.* Using post-it notes, each participant was asked to write up to 10 suggestions relating to the prompt: *What are your feelings towards your internet use in everyday life? Particularly things that you like and don't like*. Participants were not restricted in what they wrote down in terms of balance (e.g. an online service they like/ dislike, or a positive/ negative activity the internet allows them to conduct). Post-it notes were later arranged into themes and summarised back to the group.
3. *Table discussions.* Grounded in prior work (Sandvine, 2018; Widdicks et al., 2019), participants were asked to discuss how their device and service use did, or did not, involve time and data demanding categories of internet use. One table was asked to focus on the watching of video; and the other the use of social media. Discussions were semi-structured with prompts from the organisers using themes from the post-it notes where necessary to keep the conversation flowing.
4. *Designing moderate and meaningful internet use.* The subsequent design session was framed around the following fictional scenario, intended to ensure participants did not focus solely on their own personal opinions and experiences, and avoid issues of defensiveness around disclosing their own use:

   "*Pretend you're a designer of internet applications or technologies. There a set of users that are [streaming video/ accessing social media] for many hours of the day and wish to moderate their use. In groups, how can you redesign internet applications or technologies to create more moderate and meaningful use for these users?*"

   Participants were asked to critique their ideas and make notes as they discussed them, thinking about the associated challenges, advantages and disadvantages in preparation for the prototyping and evaluation sessions to follow. A definition of meaning was explicitly not provided.
5. *Prototyping designs.* Building on the design exercise, participants were then asked to prototype the group's ideas through storyboarding—helping visualise how a proposed design might work in practice. Two storyboard samples (one short, one long; both not related to digital technology) were provided to the participants to help those not familiar with the concept of storyboarding. Participants were welcome to create storyboards collectively as a table, or in smaller groups, or individually based on the number of ideas they had designed; if multiple ideas were being storyboarded, participants prototyping individually or in smaller groups were asked to draw ideas different to the others on their table.
6. *Evaluation session.* Each table was asked to present their designs back to the entire group. This allowed for comments and critiques to be captured, helping identify the common designs and challenges across both the watching and social networking categories—as well as other services that the participants ended up discussing (e.g. news sites, music services).

Table 1
The participants. Workshop topics are denoted (W) for watching, (SN) for social networking. Since the study, we have recognised that gender identity is not sex; we have chosen to maintain the participants' genders as female (F) and male (M) to follow the study data, and our participants did not identify with a gender beyond these binary terms. UG is an acronym for undergraduate; HR stands for Human Resources.

P#	Demographic Information (Age Range, Gender, Occupation)	Workshop (Topic)	Typical Internet Use
1	10s, M, UG Student	W1 (SN)	Streaming video
2	20s, F, PhD Student	W1 (SN)	Researching, social media, streaming video
3	30s, M, PhD Student	W1 (SN)	Social media
4	20s, M, PhD Student	W1 (W)	Streaming music and video
5	20s, F, PhD Student	W1 (W)	Streaming music and podcasts
6	30s, M, HR Training Assistant	W1 (W)	Reading the news
7	10s, M, UG Student	W2 (SN)	Social media
8	30s, M, Software Developer	W2 (SN)	Social media, streaming video
9	10s, F, Secondary School Student	W2 (SN)	Communication, social media
10	30s, M, PhD Student	W2 (W)	Researching, entertainment, communication
11	40s, M, PhD Student	W2 (W)	Researching, communication, streaming video
12	20s, M, PhD Student	W2 (W)	Researching, streaming music, video
13	20s, M, UG Student	W2 (W)	Online gaming, streaming video

3.2. Data analysis

The workshops resulted in 11 hours of workshop discussions (omitting workshop breaks), 107 post-it notes, and 23 storyboards (9 from workshop 1, 14 from workshop 2) for analysis. Both workshops were fully transcribed and thematically coded into themes within: accounts of the participants' current digital experiences, the moderate and meaningful designs they discussed, and the challenges evoked by these designs. The workshop post-it notes were also coded into themes of positive or negative experiences towards digital device or service use (61 positive, 41 negative, and 5 neutral), and digital copies of the prototypes were made. We also thematically analysed the moderate and meaningful designs that the participants created in the workshop (Section 5). All analysis was initially conducted independently by two researchers; themes created were then discussed and re-coded as a group with a third researcher.

4. Meaningful interactions and opportunities to be moderate

Our participants' experiences of digital device and online service cluster into the following four themes: 4.1) participants search for meaningful interactions in communication; 4.2) the (sometimes overwhelming) availability of online content; 4.3) awareness and interventions around overuse; and 4.4) issues of trust and tracking online. Through these, we offer an understanding of what opportunities there are to moderate downward our participants' digital interactions, respecting their most meaningful experiences.

4.1. Searching for meaning in communication

Through online communication services (such as WhatsApp, Facebook Messenger, Skype etc.), participants enjoyed being able to send messages to their friends and family. This was highlighted by the post-its: *"Like the ability to immediately send a message to anyone I know", "I like connecting with friends and family"* and *"It helps me to stay connected"*. This was most valued for connecting over long physical distances: *"makes the world a small place. Contact over distance is almost instant"* and *"Like WhatsApp is a worldwide 'free-of-charge' service to connect anyone"*. P2 later emphasised that Facebook Messenger helps her to keep in contact with friends around the world, highlighting that: *"it'd be really really hard, I mean if you used email, the chances that you just lose contact with many of them is really high"*.

Communication was sometimes interlinked with other digital content and services. P13 discussed how streaming UK TV hit show "*Bodyguard*" soon became *"a way of keeping up with* [his] *mum more than anything"* due to the communication they engaged in after each episode. P8 'confessed' to using Tinder and Couchsurfing hangouts *"just to make some friends"* as he moves around the world. P11 also discussed how he was able to interact with his friends from home (an 8-hour time difference away) using both social media and YouTube: YouTube members would make videos available about his home country's news (for a short time period, as they would shortly be taken down due to copyright issues), which he would then watch in order to be able to discuss local news with his friends on social media. P11 stressed how he *"need*[s]*to get updated with all this stuff"*.

The perceived negative impacts of connectivity revolved mainly around social media (e.g. Facebook, Instagram, Snapchat), rather than the instant-communication apps available. Whilst Facebook Messenger allowed P2 to keep in contact with all her friends, she described Facebook as *"a love-hate relationship where you would like to go without but you can't"*. P5 mentioned how she hates having Facebook on her phone, stating that: *"as much as I love dogs, I don't really care about seeing them throughout the day"*. Less meaningful content was also present for P9; she tried to stay away from the main homepages of social media sites and just use them for messaging as *"the things you see* [laughs] *like it's complete nonsense"*.

4.2. The availability of online content (and its potentially overwhelming volume)

Access to content, gathering information and learning were important to participants as indicated by the post-its: *"Curiosity—always able to find answers to questions", "Provides access to lots of information"*, and *"Great for educational purposes"*. This was often linked to the benefit of timely access, e.g.: *"I like being able to find things out 24/7", "I like keeping updated about news and social trends"*, and *"Like having the answer to nearly any question nearly instantly"*. P10 found access to, and notifications of, news *"within a few seconds"* particularly valuable.

Other positive experiences surrounding access to content included: the ease and availability of digital devices and services e.g. *"simple extremely accessible and easy to use to help along with day-to-day tasks"* and *"Available in most places"*; the functionality of services e.g. *"Like online banking"* and *"Like the internet for navigating around i.e. use Google Maps a lot when I don't know where I am going"*; and the range of entertainment available e.g. *"is an incredible source of video, music…far better than CD/DVD ages", "Great accessibility to services to build your own 'world' [of entertainment]"*, and *"Like entertaining—there is a meme for everything"*. P5 discussed the availability of video content in relation to her insomnia: *"now, I can watch anything, it can be something exciting, it could be boring if I want to go to sleep…accessibility is good"*.

Three post-its highlighted how this expanse of data could lead to negative experiences: *"The sheer volume of information can be intimidating", "Over-whelming (too much info*[rmation]*/too many offers)"*, and *"The 'always on' nature of the internet can be a bit intrusive"*. Furthermore, P12 recounted how he will watch entertainment online just because it is available, but questioned whether he should be making better use of his time; he then went onto say that sometimes he wishes for series *"that last forever"* to be cancelled, as whilst it is still running, you want to keep up. This highlights aspects of "fear of missing out" (FOMO) due to the growing volume of online content available. To avoid missing out on social interactions, P2 felt socially pressured into buying a Netflix subscription to watch content that others had recommended. P6 also highlighted his experiences of FOMO:

> *"there's so much out there and you can get it whenever you want…you kind of feel like you're missing out if you're not constantly on the internet and not constantly reading or watching to something…cause you could be doing, all sorts of different things, so it kind of feels like a waste to be doing nothing, even though it's a very good thing to do, to sit and do nothing for a bit"* (P6).

P6 pondered whether the internet makes it easier to switch entertainment off as it's always available at a later date—unlike historically, whereby a TV show would be shown once on broadcast media and it may not be shown again. Yet his own experiences of switching off can cause him to feel like he has wasted his time. This feeling of wasting time links to P5's worries about whether people (particularly children) know how to be bored anymore, due to the variety of content available on the internet: *"everything's a possibility now so it's like would I ever be bored again?…I think* [boredom] *inspires things like creativity or going outside in the world"*.

4.3. Awareness and interventions of overuse

The "overuse" of devices and services were highlighted as having negatively impacted participants. The post-its highlighted: *"Easy to overuse by accident", "Distraction—not good, easy to get lot on other websites", "Addiction (can't go without)"* and *"Fear (Future to come) increase dependency"*. Five of the participants (P3, P7, P8, P9, P11) implicated notifications in drawing users onto their devices and services.

P9 discussed how YouTube wastes a lot of her time as *"you just get sucked into it, and go down a hole"*—adding that this video content is meaningful if it is being used to educate you, but not if it's *"just like useless, just entertainment"*. To mitigate accidental use and distractions, P11 silences his phone to avoid looking at notifications, and P3 confines his social media use to the evening to avoid it interfering with his work. P1 attempts to control his social media use by having removed such applications on his smartphone, and only accessing his social networks via his laptop's web browser.

P13 no longer takes his smartphone into his bedroom due to temptation of use leading to wasted time before work. P12 and P13 discussed how, just by being on devices can lead to potentially unwanted device or service use: P12 finds it easier to not watch content when he is doing non-technology related tasks, but that *"doing things on a device has a temptation…'what if I don't work, but watch this instead?'"*; and P13 agreed with P12: *"you could go to that computer or phone or whatever with wholehearted like…'I'm gunna work' and then you're like…type N-E-T-F-L-I-X"*. P6 discussed how he sometimes misses the earlier time when only one computer was available in the house. Contemplating whether more traditional access to devices would help create more meaningful experiences with and without digital devices, P6 said:

> *"you'd have a specific purpose and you'd have to say, right I'm going to go sit at the computer and do this, and then when you're not doing that, you're doing something else, and the internet's just out of your head and you're actually, switched on to the rest of the world"* (P6).

P5 highlighted that *other* people's use of digital devices and online services can cause concern—complementing P13's frustrations with family members spending time on their devices when he is trying to spend time with them. P5, on the other hand, described her disbelief during an anecdotal experience on public transport with strangers:

"I was just staring out of the window, like looking outside and I turned to look at the bus and literally everyone was just like a white screen in front of them and I was just sat there like, I don't, I didn't feel the need to, I just like enjoying looking outside because I wasn't at my office staring at a screen" (P5).

4.4. Trusting online services and feeling tracked

Trustworthiness of services, being tracked and concerns around privacy were discussed in relation to online services. Post-it notes covered lack of trust in other users due to forms of technology misuse and abuse (*"Dislike misuse of IT e.g. fraud, cyberbullying"*, *"Dislike abuse of people, intolerance"*), as well as the lack of trust in the data that is accessible (e.g.: *"Dislike the quality of the content because it is free and open"*, *"censorship 'fake news' faster to spread"*). The participants did not always trust the online services to handle their data with care: *"Worry about where all my data goes and what it is used for!"* and *"Dislike how accessible our information is (vulnerable feeling)"*. This seeped into worries of being tracked online (*"Dislike constant background feeling of being tracked and monitored"*) and the use of this data to then predict what should be shown to them (*"Dislike social media & entertainment apps that collect data and predict preferences"*).

Participants who were most concerned about their privacy seemed to have additional knowledge about technology (P1–2, P4, P7, P13). P4 highlighted that we: *"have accounts on all of our devices that record everything we're doing [...a] Google account"*. P7 gave the example of Android apps, e.g. Flashlight, asking for permissions it wouldn't need for the app's functionality prior to GDPR (General Data Protection Regulation). P2 described Facebook as a *"nightmare"* for privacy: *"I'm pretty sure they use all the information that I type to like, sell it someone to, sell me something that I don't need or want"*. P13 also raised concerns about Facebook regarding the Cambridge Analytica Scandal (Cadwalladr and Graham-Harrison, 2018). P1 attempts to minimise his social media use to avoid his personal data being scraped—all due to issues of *"surveillance culture"* (P1) and the lack of transparency over data sharing for advertisements:

"I think the sponsored ads are okay cause they're a company and they need to sponsor themselves somehow, but it's the ads like you say that follow you around...if you see an ad, something that you've researched before, your brain will go 'oh okay, they've used that information, then how else have they maybe used it?' and you don't know" (P1).

Contrasting reactions to issues of privacy and trust arose in the discussions. P2 joked of the idea of removing all personal data from her Facebook page and instead using a flower as her profile picture (rather than herself), P3 discussed how he has already made efforts to change his social media use for reasons of privacy: he and his family no longer share photos or visual media on Facebook, but instead use it for textual information. Counteracting this, he described how he's noticed a trend from his friendship group shifting their shared personal posts from Facebook to Instagram: *"I don't know if it's secure or something, but somehow the trend has changed in the past year or so"*; it was not clear whether P2 was aware that Facebook owns Instagram.

4.5. From experiences, to designs

From our workshop discussions, we found that there are nuances of meaning within online social experiences—with different services (e.g. video streaming) adding to meaningful communication. The participants enjoyed the availability of content, particularly how easy and quickly it could be accessed. There were cases where this volume of data was seen as overwhelming, and where device and service design can make it easy to 'overuse' digital technology—highlighting opportunities to moderate such experiences. Participants also raised concerns about how their own personal data is used online and the effects of feeling tracked, showing that some aspects of data demand not directly meaningful to users.

5. Designing moderate and meaningful digital experiences

We then moved on to explore with our participants design ideas that aim to overcome their negative experiences by encouraging more moderate interactions, retaining the most meaningful digital experiences. We describe the designs produced in the workshop (Table 2) and summarise the challenges our participants raised for embedding these designs in their lives. Ultimately, the workshop participants built upon their own experiences with digital devices and services, producing design storyboards. Note that our categories below were developed through our own thematic analysis of all of the workshop data and materials, including those of our participants, and not directly from the storyboards. We provide sample storyboards as supplementary material.

5.1. Feedback: awareness and alternatives

A prominent design idea that emerged involved giving more awareness or salience of their device and service use, providing moments for users to reflect on their usage, and suggesting alternatives to such use.

1. *Awareness of use.* A significant majority (ten) of our participants emphasised that the designs could raise awareness of how, when or what they use technologies for—helping the participants (P6, P13) and users who are already self-motivated to moderate their least meaningful use (P7). Reflecting on iOS's self-monitoring tools, P3 envisioned this information becoming integrated as part of current services—e.g. Facebook *"it could have an update side bar which tells you what you have been doing"* whilst P11 envisioned feedback as periodic and more aggregate monthly, weekly or daily reports via email. P9, P11 and P13 also mentioned using forecasts of predicted use to persuade users to moderate (e.g. *"'in the next 30 years, the amount of time you've spent on Netflix is going to be like 10 years' or something"*, P13). P1 suggested that people may be less inclined to use the internet if they were aware how their personal data was being used by online companies.
2. *Providing moments of reflection.* The idea of "mindfulness" was favoured for the watching related designs. P4–6 in particular wanted to focus on positive ways to moderate, providing *"more carrots instead of less, and less sticks"* (P5)—creating tools which helped the user make *"more deliberate"* (P6) decisions that are meaningful to them, rather than being dictated to by an app designer. They imagined this in the form of the user selecting personal mental health, sustainability and meaningfulness goals, for which an app would then provide milestones to reach (e.g. reduce Netflix to 2 hours a day to reduce online CO_2 emissions) and visualisations of these milestones

Table 2
The workshop designs.

D#	Design Group	Designs
1	Feedback: awareness and alternatives	*1) Awareness of use; 2) Providing moments of reflection; 3) Suggesting alternatives*
2	Setting limits	*1) Limited, yet flexible, access; 2) Limiting usage sessions; 3) Limits at specific moments of everyday life*
3	Sensors, location and context	*1) User senses and device sensors; 2) Location data and movement*
4	Merging virtual and real-world experiences	*1) Encouraging real-world interaction and support; 2) Gamification and competition; 3) Incentives and rewards*
5	Attenuating the user experience	*1) Modifying colour, brightness and imagery; 2) Preventing interactions; 3) Producing finite content and feelings of sufficiency*
6	Integrative designs	*Combinations of design groups 1–5*

to reflect on. Rather than a separate mindfulness app, P1–2 suggested embedding such reflections within apps: emails and notifications would display motivational messages, quotes or reminders of tech-dopamine effects.

3. *Suggesting diverting alternatives.* The participants proposed that options could be provided to users to show them how they may have, or could, 'better spend' their time, for example: learning a language instead of scrolling on Twitter (P5); getting fit or earning money instead of spending time on devices (P7). P9 and P10 suggested swapping online time with like-for-like activities e.g. for entertainment, designs could suggest to users to listen to an audio book, or attend a local event to replace the online *"end product, which is entertainment or fun, or just killing boredom"* (P10). P12 extended P10's idea and drew upon his experience of using a video recommendation app, proposing that activities could be recommended based on what he has watched for *"breaking the momentum of the* [streaming] *consumption"*; e.g. fans of *The Great British Bake Off* (a UK cooking show) could be provided with recipes to make from the show.

5.2. Setting limits

Tools that allow users to set specific limits on their use were popular in the workshops—following from features available in digital wellbeing tools (e.g. Torres, 2019 and Apple, 2018). We detail three variations of limits-related designs prominent in the workshops below.

1. *Limited, yet flexible, access.* Four participants (P3, P10–11, P13) suggested users could have a specific amount of time to access a service. P10 imagined this embedded in apps e.g. limits to hours spent watching on Netflix that the user would be unable to work-around *"unless of course* [they] *create another account"*. P10's table discussed the challenges of such a company making these designs, yet P13 proposed *"'Netflix is helping people stopping binge watching'"* as a marketing strategy. P3 offered data usage as a limit, based on his experience of having a 2 GB/month bandwidth quota at university where internet speeds slowed after the quota was met. Two versions of his social media design were prototyped: 1) where the user can no longer access a service after the limit; and 2) where the user can access a 'Lite', text-based version of a service after the limit, with all the 'fun' (pictures, videos) removed and centralising the core meaningful interaction of communication (see Section 4.1).
2. *Limiting usage sessions.* Rather than having a time limit to using services in a given period, participants also suggested restrictions for specific *sessions* of use, e.g. *"a timer to keep track of what you're doing"* (P10) linking to TV parental control systems (P3) and Spotify's 'sleep timer' (P9). With these per-session limits, more novel approaches (as opposed to time) were discussed. P7 described reducing the number of times a user could refresh content. P9 suggested how screen length (*"about 4inches"*) could be utilised, with users having a maximum distance in which they could 'scroll' (e.g. on social media) which were compared with physical real-world distances: *"'oh you've ran like erm the whole perimeter of Manhattan'"*. P8 proposed limits on *"compulsive"* session use based on scrolling speeds: *"keep from scrolling erm fast,* [on] *Instagram, probably it's not, it's not meaningful to me and is only making stress..."*.
3. *Limits at specific moments.* A more complex aspect for user-set limits involved a broader understanding of events or activities occurring within the users' lives—particularly for work tasks, building on knowledge of productivity tools already available (P5). Given W2's discussions on watching for entertainment versus watching for work-related procrastination, the table organiser asked whether machine learning algorithms could be utilised to determine if users were on-time with their work deadlines—blocking streaming activities if not. P13 exclaimed how this might help him manage his video streaming and university deadlines. Users could set their own limits during specific time periods, alongside aid from the digital tool itself as it 'learns' the rate at which a user works, the time left for a deadline, and the amount of internet use that may be 'acceptable' in these constraints.

5.3. Sensors, location and context

Six participants (P1, P4, P6–9) suggested utilising different aspects of users' physical bodies, sensors available on devices, and spatial information of the users' location within the designs.

1. *User senses and device sensors.* Using the human senses and physicality was a more playful aspect of design that the participants discussed, e.g. *"gloves you wear that makes it hard for you to use your phone"* (P4). P9 designed a 'fidget toy smartphone case' that included prompts from the device for the user to interact with *"clicky rocker switches and then little buttons"*—giving users something to do instead of scrolling without meaning online. P8 comically described how he regularly drops his smartphone on his face in bed as he falls asleep; he designed a tool to detect this scenario by measuring device movement and when a room is dark (via a device's accelerometer and light sensors), using alerts to encourage the user to get some sleep. Device sensors were also suggested for facial tracking to prompt users to look up from their screens (P7) and to turn off videos if users are not concentrating on content (table facilitator).
2. *Location data and movement.* Four participants (P1, P6–8) proposed using locations and movement detection in their designs (e.g. by using GPS data). A popular location for envisioning moderated use were users' workplaces: blocking social media apps (P7) or muting notifications (P8). P1 discussed blocking internet access in a workplace's break spaces: *"people would be forced to talk to one another...it would strengthen the teamwork aspect...in the utopian scenario"*. Other locations suggested for moderating use were dangerous roads (P8) or specific rooms in the home (P6). Movement was also discussed as a way to determine meaningful interactions (e.g. *"if I'm kind of on-the-go and doing other stuff I'm only likely to read, or respond to notifications that I'm interested in"*, P7) or as a technique for moderating them (*"'hey walk for 300 metres and then you can use it again'"*, P8).

5.4. Merging virtual and real-world experiences

The participants discussed using social influences in the real—(i.e. physical) world for their designs: promoting real world social experiences, creating competition with others via gamification, and developing incentives and rewards.

1. *Encouraging real-world interaction and support.* Three participants suggested using real-world social interaction and support for the designs—connecting friends, family, or other users moderating their use to *"support each other"* (P1) or *"share your experiences"* (P3). P3 developed *'The Healthy Internet Programme'*: an app which would provide the user with different activities e.g. sending a physical greeting card instead of an e-greeting or social media post. P8 proposed a playful idea of integrating support from others into social media moderation: if a user continues to overuse a service in a way which is no longer meaningful to them, the device could post a photo of the user to their friends with the caption *"'Please help me, call me, let's go out for a beer, I have an issue with social networks'"*. Given the privacy issues, the W2 participants discussed how it could be a humorous, consent-driven design sent to only a few supportive, user-selected friends.
2. *Gamification and competition.* Seven of the participants (P1, P3, P5, P7–8, P12–13) suggested fun gamification or competition features in their designs. These were based on previous experiences (e.g. P3's family "FitBit" step challenges, P13's family 'Super 6' football score guesses), and included ideas such as a family monitoring their social

media use with the highest user having to pay for a meal (P1) or donate money to charity (P3). Rather than a monetary "fine", P1 created "*The Forefeit Incentive*" app where a group of users (e.g. friends in a shared flat) would commit to a forfeit such as washing up. Designs were also gamified through virtual rewards e.g. badges (P11), virtual money (P13) and tokens (P7) for device or service non-use. P7 and P13 envisioned money and tokens would be "spent" on interactions, enforcing blocked or limited access after they were spent.

3. *Incentives and rewards.* Eight participants (P1, P3–6, P11–13) discussed the need to incentivise and reward people—keeping users motivated (P1) and happy (P4, P6), as well as changing their habits rather than just raising awareness of usage data: *"why would I change if I see the data? Data informs me and communicates, but it doesn't affect* [me]*"* (P12). Financial incentives were suggested[1] but P1 speculated that rewards might not necessarily have to be monetary-based given users use search engines to plant trees or count steps on FitBit: *"there's no economic benefit for that but people feel pretty good about themselves"*. P12–13 had similar discussions surrounding the value of rewards, e.g. *"the value of Nectar* [a UK reward program] *points isn't significant but then people keep collecting them and get upset when they remove them"* (P12).

5.5. Attenuating the user experience

Instead of separate apps or devices for their designs, the participants suggested intentionally *reducing* the quality of the user experience to moderate time online using a range of ideas: modifying colour, brightness and image quality; preventing interactions; and producing intentionally finite content.

1. *Modifying colour, brightness and image quality*. To reduce the user experience, P1 explained the 'science' behind modifying colour: *"if you turn it into black and white, it'll neurologically be less of an incentive to use that device"*. P2 saw colour removal as a *"good compromise"* between reducing the user's experience and making them frustrated, *"gradually removing colour"* the longer that users spend time on the service or device—a concept P9 also proposed for turning down the screen's brightness. Building on the idea of using imagery to enhance teaching materials, P3 suggested removing *"access to photos or videos or something dynamic [...] that might eventually reduce your interest in an app"*. This would still allow for meaningful data to be accessed, as P7 notes: *"images tend to be more either promotional from companies or just random social stuff, messages tend to be like the text seems to be more important"*.
2. *Preventing interactions.* The ease of access to devices and services, and notifications, were seen to pull users into use sessions (Section 4.3)—therefore P8 suggested that notifications could be muted or delayed (e.g. during users' sleeping patterns), and P1 and P2 discussed that designers could make it *"tricky to get to the website"* (P1) to avoid ease of access to meaningless interactions. For such 'tricky' access, P2 and P7 described slowing internet connections e.g. after a user has *"been using* [a device/service] *for a certain period of time"* (P7); slow connections already prevent P2's, P8's and P10's use. Similarly, P2 suggested a *"less intrusive"* design to blocking service access could *"close the app after a certain amount of time"* to prompt users to do something else; yet she also proposed that social media access could purposely drain more device battery so users would prioritise their meaningful interactions.
3. *Producing finite content.* The participants proposed adapting online content to be more finite e.g. to prevent infinite, meaningless scroll on news articles (P4) and on Facebook—suggesting less elements could be loaded *"to slow down...the scroll"* (P8), and filling users' social feeds with *"older stuff more and more, with very little new content"* (P10). P7 noted finite content designs are already offered by Instagram and Twitter, and discussed with a table facilitator how designs could produce new content at specific time intervals to 'drip feed' content to the user. For watching, P12 said that *"maybe* [Netflix] *need to stop releasing the whole season"* at one time, to avoid negative effects e.g. binge watching; he also described how designs could 'trick' users into thinking there is no new content—*"misleading the user for the greater good"*. This was seen as a good way to fool the user (P13) rather than explicitly forbidding access (P12).

5.6. Integrative designs

Six participants (P3, P5–9) specifically suggested that the designs described in the workshops could be merged to develop a more complete design that moderates use and centralises meaningful interactions. P3 and P7 discussed the potential of raising users' awareness through reminders of their usage limits; P3 suggested limits and rewards could be combined; P9 discussed that P8's movement design could be linked to P7's token system; and P8 proposed combining the best features of his group's designs. P5–6 also envisioned that P3's reduced image content design would merge well with P1–2's colour fading idea, and P6 saw that this could link to the target setting design that his group discussed. In fact, P7's prototype consisted of a complex design merging four of the five design groups summarised in Table 2: users could accrue points for not accessing certain apps and lose them when they did (gamification); once points were diminished, users' bandwidth would be slowed on specific services (preventing interactions) or the use of those services would be restricted (setting limits); and users would receive a summary of their use and what they could have done instead if they had put their time into something else (awareness of use and suggesting alternatives).

5.7. Challenges

We felt the participants were highly engaged and innovative throughout the workshops and as a result were able to offer us considerable insight into their experiences of interactions with devices and services. However, they also recognised certain challenges with their designs would raise if taken forward.

Critically, given the way these services are paid for, they discussed the difficulties in bringing businesses on board given potential threat to their revenue streams (P1–3, P7, P12–13). Also, the need for regulation (P6) to avoid inequalities of use across users (P4). They worried about the agency, availability of choice and impacts on users: ensuring users are not being controlled (P1–2, P4, P12); that they don't have 'extra work' to do (P2, P6); can still access their devices in emergencies (P1–2, P6–7, P13); and the privacy implications of designs requiring some form of tracking (P3–9, P12–13).

Related to this, they discussed the challenges surrounding the higly subjective nature of meaningful device and service use between users (P2, P4–6, P8, P12–13); and the possibility of users creating workarounds, or 'cheats', to continue their current usage patterns (P1–10) around any limitations that might be designed in. Finally, participants highlighted concerns regarding the implementation of these designs: the potentially counter-intuitive nature of creating devices or services to moderate devices and services; ironically facilitatating other digital interactions (P5–6) or leading to "rebound effects" of potentially creating more use of the internet or digital devices (P1, P4–5, P9, P12) when trying to mitigate this in the first place. Plus the technical challenges for creating moderate interaction designs that span across the range of devices, services and activities many have access to (P1–2, P4, P7, P9).

[1] The participants did not mention the Hold (2019) app, which allows users to gain points from spending time away from their device. These can be spent on discounted products or services in the real-world (e.g. free popcorn at a cinema).

6. Implications for moderate and meaningful interaction design

It's clear that too much engagement with digital technology has a wide range of implications, not just in environmental sustainability terms. For our participants, some found it "too easy to access", "distracting", and felt that "time was lost" to sometimes low profit, meaningless interactions—to the extent that some were already developing strategies to mitigate this. As HCI research on wellbeing, work productivity, relationships and online privacy, and others (Section 2) have noted, these impacts are concerning, quite possibly growing, and they are multidimensional. We now explore what we see are the clearest implications arising from our study and this prior body of work, for designing moderate interactions with devices and services whilst centralising meaningful experiences. We draw particular emphasis to our novel implications through the use of bold text.

6.1. Internet speed bumps as barriers to (re-)entry

The participants' accounts show that they can find it "too easy" to access, and become distracted by, digital devices and services. In fact, some purposefully try to avoid using certain services that they find difficult to extract themselves from, and have even introduced processes to enforce an entry barrier (Section 4.3). Similar findings exist in productivity research, as workers create *"micro-boundaries"* to accessing their email (Cecchinato et al., 2015, p. 3996); these micro-boundaries are defined as "*a small obstacle prior to an interaction that prevents us rushing from one context to another*" (Cox et al., 2016, p. 1392). Such micro-boundaries could be utilised to create moments of reflection (Section 5.1) to allow more moderate and meaningful interactions with online services by enabling users to reconsider if they actually need or want to carry out the interaction.

Furthermore, as our participants discussed, and as prior work points out (Lord et al., 2015; Widdicks et al., 2017): users often check and use their devices or specific services, often just because devices are "there" (Section 4.3), or perhaps due to fears of missing out on online content (Section 4.2). Barriers to **re-entry** may provide data reduction opportunities by removing the ability to continuously refresh content when revisiting an application (Jones et al., 2015). This could be linked to enforced user movement (e.g. via GPS tracking; Section 5.4) to promote digital wellbeing using contextual data, echoing a call made by Monge Roffarello and De Russis (2019) for digital wellbeing tools.

Prior work suggests creating barriers by requiring users to carry out cognitive tasks before accessing specific apps (Kim et al., 2019a; Park et al., 2018)—aiming to engage users in "*cost-benefit analysis for self-regulating frequent app use*" (Kim et al., 2019a, p. 9). However, such interventions focus on smartphone applications, and concerns surrounding digital device and services go beyond just mobile devices (cf. Lascau et al., 2019; Monge Roffarello and De Russis, 2021). We suggest a holistic approach across device and service use whereby boundaries to interactions could exist through **internet speed bumps** (e.g. bandwidth throttling at the network or router level), allowing users to retain internet access whilst filtering specific actions (and associated data demand) that are less meaningful or not worth waiting for. Kovacs et al. found that work productivity tools on one device do not redistribute procrastination onto other devices (Kovacs et al., 2019), but this may not necessarily be the case for tools to alleviate other negative impacts (e.g. on our wellbeing). As internet speed bumps would target all of a user's devices, switching devices to avoid the barrier would not be as easily achieved.

Internet speed bumps could also be "more physical", for example by identifying certain workplace locations for disconnection (Section 5.3). Dedicated spatial "internet-free zones" could be introduced in e.g. quiet zones or break spaces at work, or when family are collocated in the home (Oduor et al., 2016). The speed bump would require the user and their device to move physically out of the internet-free zone, for internet connectivity to be restored. Yet, it is important to note that these internet-free zones would challenge the user expectations of "always on" connectivity and universality of access—both important to some participants (Section 4.2), and which may have become more important for work and contact with others during the COVID-19 pandemic.

6.2. Interaction flows for ease of exit

As some of our participants find they can become trapped within applications (Section 4.3), it is important that there are mechanisms for users to easily exit their use of these online services—encouraging users to leave services after their original purpose has been achieved (Lukoff et al., 2018). Our workshops uncovered different design approaches through which such 'interaction flows' could be introduced, making it easier for a user to end a session and thus reducing the data demand associated with prolonged interactions. Deploying these may be most useful when users are already somewhat disengaged with the content that they are interacting with, e.g. evidently scrolling too fast to truly concentrate on online media, or when devices are dropped when falling asleep (Section 5.3).

A directed approach could include auto-closing apps (Section 5.5), or timers and scrolling limits (if applicable) to be placed on sessions (Section 5.2). Such *"self-defined limits"* e.g. *"natural stopping points"* to device use have previously been recommended by Hiniker et al. to transitioning children away from their devices (Hiniker et al., 2016, p. 657). As we highlight in this paper, such limit-enforcing designs would be useful for people more broadly (i.e. not "just" for children). Similarly Okeke et al. suggest negative reinforcement "vibrations" to warn of social media "overuse" (Okeke et al., 2016). Interventions like these may be particularly valuable for services that our participants describe as addictive (e.g. Facebook, Buzzfeed, Reddit, Instagram, YouTube).

Our workshop also highlighted new ways in which interaction flows could ease exiting through less explicit, or "softened" means: by **intentionally attenuating the user experience** of such services (Section 5.5), making the interface less "addictive" and therefore easier to exit. Such flows could be introduced over time by gradually removing colour or degrading image quality, intentionally increasing loading times as more and more content is requested, or even producing the same content that users have already seen to intentionally induce boredom or a sense of closure. These types of design are antithetical to so called "persuasive designs" already widely practiced in the industry (Fogg, 2009) to promote user engagement and attention with digital services—yet these flows from reduced user experience would be useful to explore in designing moderate and meaningful interactions.

6.3. Adding metadata layers

Another prominent theme in the workshop was the discussion of online privacy and trust in service providers, or lack thereof (Section 4.4). Participants were concerned about data sharing and tracking, were not always sure what their data was being used for, and struggled with the lack of control they had in protecting it. This is not a surprising finding. There have been a number of calls for increased transparency and control within design to promote privacy (Eslami et al., 2018; Fiesler and Hallinan, 2018; McReynolds et al., 2017; Van Kleek et al., 2018), ensuring that users are "*better positioned to make decisions that meet their privacy and functionality expectations*" (Wijesekera et al., 2018, p. 10) or are fully informed about privacy and security issues when purchasing devices (Emami-Naeini et al., 2019). With this in mind, we suggest that layers could be added onto services to provide "metadata" about what information is being captured from users' interactions with online services—providing *"notice"* of what the service is doing (Langheinrich, 2001, pg. 8) in the moment and acting as a form of network-based, personal privacy assistant (Colnago et al., 2020). This would help alleviate the concerns that the participants faced, as well as create greater trust between service providers and users through openness.

Inspired by our design workshop, we suggest implementing feedback layers that facilitate awareness (Section 5.1), showing what data the service provider now has (and how they might use it) based on the user's interaction. Designs following this idea would need to ensure they work across services, as service providers share data across their websites or apps; this therefore may require displaying full network traces across linked platforms in a user-friendly manner. We thus note that the creation of metadata layers would be useful for **new use cases beyond "just" improving users' online privacy**: with more information of how users use their services, as well as transparency on **how services utilise this information**, online service providers can be held accountable for data demand associated with personal data sharing. As P21 highlighted (Section 5.1), making data more open may also lead to users potentially becoming less inclined to use the service and reduce user-initiated data demand. Moreover, we also suggest that users could be given opportunities to **interact with this metadata**, blocking the sharing of personal data in a similar way to how web advertisement blockers work and reducing the associated data demand. With this, users can also be empowered to better control their usage overall—moving beyond, for example, just raising awareness of the users' time spent on a service and their usage goals (Lyngs et al., 2020).

6.4. Stripping back layers of service

We suggest looking for ways in which "**layers**" **of services can be 'stripped back' to only contain the content that is most meaningful to the user**, thus reducing the data demand associated with non-meaningful content. For example, in the case of Facebook, layers of imagery (images, videos, advertisements) could be removed (Section 5.5) to leave only a layer of textual or informative posts from friends or family—prioritising communication (Section 4.1) over richer media. This would be one way of *"altering the information landscape"* suggested for future designs for digital self-control (Lyngs et al., 2020, p. 10). We would of course acknowledge that to do this would prioritise the user and environmental concerns over the current revenue streams of these services, which is a broader challenge for the industry if it is to meet growing expectations and regulatory requirements for privacy and climate friendly designs.

This stripping back of layers could be introduced after a usage limit has been reached on accessing the original full-service version (Section 5.2). Such lower layers of service might act similarly to the 'Lite' versions of applications that currently exist for countries where data access is limited. We could experiment whether imagery should be removed in its entirety, or whether users could "click to load" elements (similar to Twitter Lite's "data saver mode" (Lite, 2020)) after a limit has been reached; the latter allowing for users to subjectively make purposeful decisions about what content is meaningfully significant (Mekler and Hornbæk, 2019) or preferential (Lyngs et al., 2018) to them.

Stripping back layers of services in this way may be more challenging for some services than others (e.g. Instagram which is image-centred), however alternative forms could be introduced. For example, summaries of information could be provided rather than detailed accounts; e.g. the BBC's news summaries designed to be read in five minutes. Such reductions in the amount of information available may help users who experience fear of missing out or "FOMO" (Section 4.2) as they can access the "most important" details quickly. Furthermore, high-definition (HD) streaming could be stripped back to standard-definition (SD) e.g. imposing limits or offering special "celebratory" instances (cf. Ferdous et al., 2017) of HD streaming less pervasively, but allowing more general access to the lower quality SD content; enabling users to continue to stream content in meaningful ways (e.g. with family and friends (Hassenzahl et al., 2013)) without putting as much pressure on the internet infrastructure (Widdicks et al., 2019) or potentially causing significant *"digital waste"* (Preist et al., 2016, p. 1330); for example using YouTube to listen to music (Lord et al., 2015; Preist et al., 2019)).

7. Discussion

While we have worked with our participants to identify clear opportunities emerging for improving app and service design to enable more moderate and meaningful digital experiences, it is also important to recognise the broader challenges implicated by these proposals that go significantly beyond user experience design, and indeed prior work (Widdicks and Pargman, 2019).

7.1. Workarounds and cheating the system

As our participants noted, users may find ways to *work around* designs which aim to moderate their digital interactions. For example, P2's battery draining design (Section 5.5) could be defeated by carrying chargers or extended battery packs. Additionally, if a user had exceeded a device related service limit, they might uninstall the limiter or even create a new account to start a "fresh" record (as P10 noted, Section 5.2). Users may also find ways to *cheat* designs involving gamification and incentives: e.g. if users were given incentives or involved in competitions to spend time offline (Section 5.4), they may find ways of accessing online services through devices which are not monitored or attributable to them.

The ability to find workarounds and cheat the system soon becomes an issue of how much control we give to technology instead of users (cf. Widdicks and Pargman, 2019). We certainly do not want to entirely take away autonomy (cf. Peters et al., 2018), but rather help users create a level of device and service use that is positive and beneficial for them in the long run. This is a difficult tension to resolve, particularly as the technology we create today can lead users to accepting future digital developments that they might have previously seen as unacceptable (Pierce, 2019)—and so in that sense, through designs like these, we are perhaps enabling technology to have more control rather than less in the future (Widdicks, 2020). We wonder whether there is a limit to what moderate and meaningful digital experience designs can achieve: if the user chooses to uninstall a design (i.e. app or service), or even to just ignore it, it is ultimately their decision to do so. This need for freedom has also been noted by Lyngs et al. citing the need to avoid users rebelling against a digital self-control tool design (Lyngs et al., 2020).

However, to avoid apparent addictive behaviour, checking and overuse, we suggest that if the user has consented, software could potentially have the control to override user decisions in the short-term (e.g. for an hour). Future work would benefit from exploring this issue of autonomy and control in relation to moderate and meaningful digital experiences (Widdicks and Pargman, 2019)—particularly what kinds of control are found to be most acceptable to users. HCI researchers and practitioners also need to understand exactly what device and service use is deemed as negative by users in the moment—adapting for different temporal and spatial contexts, and ensuring that the intervention actually targets addictive behaviour rather than *"simply parroting an addiction narrative"* present in the media (Lanette et al., 2018, p. 180:3). Regardless of the intervention, we must be careful to ensure that users can contact friends and family when they need to and always access the emergency services.

7.2. Complexity and unintended effects

There are a number of complexities, and potentially unintended effects, when designing to prevent the negative impacts of devices and services—some of which can seem contradictory. For example, as our participants highlighted, it may seem paradoxical to introduce more devices or services when users are trying to cut down on their use of these technologies (e.g. the gamification suggestions usually involved creating another app). These could therefore add to the problems we have highlighted, causing negative unintended effects for users or society. Lee et al. have noted the importance of considering the negative impacts that positive computing technologies can unfortunately create

(Lee et al., 2019). Such contradictions and trade-offs have also often been found in sustainability work: giving users smart energy monitors to better manage their energy consumption can actually lead users to view their energy access as unlimited, or make them feel that they are entitled to such use (Hargreaves et al., 2013; Strengers, 2011). Considering this work, it is perhaps a reason to focus on adapting current device and service designs, rather than creating more apps for users to install or manage.

We are conscious that unintended effects or conflicts could possibly be created across the themes (i.e. digital wellbeing, productivity, relationships, online privacy, environmental sustainability) that we aim to improve through designing for moderate and meaningful interactions. For example, the participants' gamification suggestions focus on improving users' wellbeing and relationships through healthy competition. However, such gamification could potentially cause rifts between families or friends if this leads to dispute—damaging relationships instead of encouraging users to spend more time together. Moreover, unintended effects could occur at a societal level—particularly with regards to privacy. For example, the location-based designs suggest the use of physical spaces to determine whether the user can access devices or services; this could require "big brother style" surveillance that may potentially be used for other (and perhaps less ethical) purposes by service providers, or even by governments (e.g. social credit systems).

This challenge of mitigating negative unintended effects is worth considering when designing for moderate and meaningful digital experiences, and certainly a challenge in which all technologists should scrutinize when designing digital technology more generally given the variety of unintended effects it can create. A possible avenue forward would be to anticipate (Stilgoe et al., 2013) and acknowledge any potential unintended effects of the design recommendations (e.g. through speculative design (Pierce, 2019; Widdicks, 2020)) as they are initially tested and evaluated in future work (Remy et al., 2018). These can then be followed by longer-term studies with the most successful designs to discover or alleviate any unintended effects (Yang et al., 2014).

7.3. Who has the power?

We return to the very obvious contradictions with the way that many business models incentivise user engagement, which is intention with moderate and meaningful design. Businesses typically want you to spend *more time* on their services to monetise your attention, and often create hooks (or *"triggers"* (Fogg, 2009, p. 3)) to intentionally draw users into performing a particular action (e.g. buying a product, viewing an advert). A design which does the opposite is unlikely to be adopted if it acts against this economic motive or threatens or exposes the underlying business model. Moreover, designs like our suggested metadata layers make the data demand from personal data sharing more transparent, exposing the business models of "free" services. While these are free in terms of monetary cost, it is presumably in the interests of service providers not to openly declare the real costs and value of data to users: their data, a resource suggested to be more valuable than oil (Economist, 2017); their vulnerabilities, such as their emotions and biases (Centre for Humane Technology, 2022a; 2022b); and, to some extent, their right to environmental sustainability given the contributing footprint of the technology. These business model conflicts take power away from any intentional design in making significant changes towards mitigating the negative effects of devices and services—but we do see opportunities to recapture such power, such as working to change the business models and regulatory frameworks that might govern these.

We once again stress that we will need to collaborate with companies to discover how moderate device and service design can work for their business and for users (Widdicks and Pargman, 2019). This would allow for compromises between businesses and users to be established redressing the power balance in the relationship, and highlight what specific designs can or cannot be deployed. Tools (cf. Hern, 2018), industry research (e.g. Team, 2020) and funding calls to push a digital wellbeing agenda forward have already been made by service providers (e.g. Facebook Research's focus on understanding Instagram users' wellbeing (Facebook Research, 2019)), and we encourage the designers to leverage these opportunities.

Designs for moderate and meaningful interactions aim to mitigate many of the negative effects associated with devices and services; so even though a funding call like this focuses on digital wellbeing, we can envision that the research can address other issues too (e.g. environmental sustainability). Furthermore, there is potential in developing effective marketing strategies with businesses. For example, data privacy has become an effective marketing strategy (Martin and Murphy, 2017), despite data mining providing businesses with in-depth information about users (especially for targeted adverts). This is also in line with marketing strategies aiming to project an image of corporate responsibility (as noted by P13, Section 5.2).

We can however, achieve some of the designs through "add-on" technology rather than directly modifying the devices or services. This is similar to how prior research has deployed interventions to digital consumption (Okeke et al., 2016); how productivity tools (e.g. StayFocusd, Forest) currently work; and, how some of our participants' designs could be envisioned (e.g. Section 5.4). These are all tools to prevent the use of other services. However, we acknowledge that, in some cases, it may be better not to design added technology at all (Baumer and Silberman, 2011; Pierce, 2012). In particular, additional devices for moderate and meaningful interactions could have implications for sustainability if they become obsolete (Cooper, 2010; Remy et al., 2015).

Finally, we note the importance of policy intervention to force organisations to comply with sustainable and ethical technology designs (Widdicks and Pargman, 2019). There have been calls for online services and the internet to be legislated in the UK (Press Association, 2019), and our community should speak to these calls within the development of research projects around this topic. This could even include investigating how the ACM Code of Ethics (ACM Ethics, 2018)—a set of underpinning principles that the ACM suggest all computing professionals should deeply consider—could become more ingrained within digital technology policy. This ethical code includes specific principles that our research study and designs aim to promote, such as *"be honest and trustworthy"*, *"avoid harm"*, *"respect privacy"*, *"contribute to society and to human well-being"* and even *"promote environmental sustainability both locally and globally"*. The code also includes ethical principles that go beyond our research focus yet paramount for our sector (such as equality), and thus offers clear goals for computing organisations' responsibility. However, engaging with policy comes with its own challenges as we may then need to create robust evidence bases (Spaa et al., 2019; Widdicks et al., 2019), spend significant time and effort understanding policy documents and language (Thomas et al., 2017), and create structural events in HCI for policy (e.g. workshops) with a range of appropriate professionals (Spaa et al., 2019).

7.4. Centralising meaning in moderate interactions

In our study, we were motivated first by environmental sustainability: aiming to reduce data demand in users' online service and digital device use through more moderate interactions. However, recognising that digital technology can have wider ranging negative effects on users, we saw this as a clear opportunity to moderate use in a way which also promotes social sustainability. Specifically, we wanted to ensure that the interactions which are moderated are not those which users find most meaningful—ensuring meaningful interactions are prioritised within any limits that might be placed upon data demanding digital experiences.

In doing this, however, we recognise the difficulty of understanding and differentiating meaningful interactions given the varying interpretations of meaning across internet users. For example, Lukoff et al. (2018) found that passive scrolling through Facebook was not deemed meaningful for their participants and rather engagement with friends is

what was deemed meaningful. Our findings equally highlighted that some of our participants shared similar views to those studied by Lukoff et al. (2018), yet for other users, passive scrolling may be considered a meaningful interaction. We also note that our participants sometimes suggested other activities to replace moderated digital interactions that may be determined as more productive in terms of personal development (such as working, learning a language) or meaningful in a Utopian view (such as interactions with others, encouraging sleep). In reality, interactions linked to procrastination actually may have meaning in peoples' lives, and ideologies of what meaningful interactions "should be" should not control this. We simply cannot presume nor determine what is or isn't meaningful to all users—making designing for interactions that do not interfere with meaningful use inherently complex.

However, by focusing our participants to consider their own interpretations of meaning, we were able to offer design opportunities to moderate meaningless interactions that do not require predetermination of what those meaningless interactions actually are. Our design implications instead are suggestions that abstract across specific definitions of meaning, allowing solutions that can be tailored to users' own interpretations of meaningful use. For example, our internet speed bumps could be introduced only at certain times or locations associated with meaningless interactions, and our interaction flows could only be introduced for services not deemed as meaningful. As a result, our designs could appropriately adapt to various devices, services, user preferences and routines, and we reiterate that the ultimate choice about how such designs are used should lie with the user.

By focusing on user interaction in our methods, we are taking a user-focused view to the issue of data demand and environmental sustainability. With this, it is unlikely that all meaningless interactions will be the most data demanding (such as video streaming (Widdicks et al., 2019)) and thus we recognise that additional efforts for designing sustainable services and devices are required. We consider the reduction of data demand from meaningless interactions as one "easy" opportunity for alleviating "growth pressure" on the underlying internet infrastructure, and suggest future research is required to further understand the social and environmental costs and benefits to moderate and meaningful digital interactions.

7.5. Limitations of our research

Our studies and findings are clearly grounded in a UK, developed economy context. Despite our efforts to recruit non-university locals, our participant pool is mostly composed of university students and young adult age groups (e.g. 18–30) who are well-educated at Higher Education-level; this is likely due to the study being held on our University campus, due to us, as researchers, requiring a free physical space to run the study. Our participants were incentivised to partake in the study through £10 vouchers; this decision was made to pay participants for their time, but may have exploited participants from low income groups. We did not ask any participants to provide data on their cultural or socioeconomic background, or their programmes of study if they were a student, and therefore cannot provide this detail. The majority of our participants were male, however, and thus we note our research has a sex-biased context; this may have been due to the topic of the workshop being grounded in Computing and the impact of Western stereotypes on women and underrepresented groups in this field. We conducted two workshops with our target participants and so our findings draw on a particular group of individuals, though this scale of study is not unusual for qualitative HCI research. In future work, additional workshops would be useful for understanding and designing moderate and meaningful digital experiences in other contexts and with a range of participant demographics. We also note that we have not included broader stakeholders (e.g. technology companies, policy makers) in the workshop design process; we purposely focus on user experience at this early ideation phase and recognise the importance of other stakeholder perspectives in future work.

Our studies were conducted prior to the COVID-19 pandemic. Experiences of internet-connected device and service interactions in terms of their importance, centrality and positive/ negative associations in many lives may have since been impacted. This means that the interactions our participants find meaningful, and those they would appreciate to moderate, could have changed; yet, as we point out in Section 7.4, our design implications are adaptable to users' interpretations of meaning and opportunities for moderation. Moreover, some of the designs our participants developed in the workshop (Section 5) already exist in the form of publicly available tools (e.g. Hold (2019), as linked to the incentive-based designs in Section 5.4). Although such tools were seldom mentioned by participants or by the workshop facilitators, the availability and presence of these tools may have influenced their designs. Our design implications, however, not only draw on our thematic analysis of our participants' designs, but also draw on the participants' experiences of meaningful interactions (Section 4), and utilise knowledge about public tools and relevant research literature in this domain. This leads to a more cohesive set of design implications for moderate and meaningful digital experiences, for which we caveat with the challenges of realistically implementing these within Section 7. We also note that the presence of these tools is a valuable asset to this research: offering clear opportunities to instantiate data demand reductions within moderated interactions.

8. Conclusion

In this paper, we focus on how "moderate and meaningful" interactions with digital devices and online services can be designed to address some of the negative impacts resulting from overuse and the growing energy demand and externality of such services. Critically, and in contrast to a coarse strategy of simply limiting or reducing access to digital services, we offer more nuanced suggestions as to how designs might reduce impacts for a concert of issues—simultaneously mitigating not just growth in energy and data demand, but also addressing potential harm to digital wellbeing, work productivity, relationships and online privacy through our moderate and meaningful design approach.

Our design proposals draw upon two workshops in the UK with 13 participants to understand users' digital experiences, what they find as meaningful interaction, and how they perceive interaction designs could help them promote better wellbeing, productivity, and address the more addictive and negative social effects they find. We offer concrete design proposals for further development and evaluation including introducing internet speed bumps as barriers to users (re-)entering services or devices; ensuring easier exits to device and service use through interaction flows; adding service layers to provide metadata on their interactions; and stripping back layers of service to retain users' most meaningful actions online.

Bringing these impacts together in simple and practicable designs is clearly challenging, not just in interaction design terms, but in the more fundamental challenges they pose to business models incentivising the opposite, and the broader eco-system of services in which they sit. We discuss these (cf. Widdicks and Pargman, 2019), and pose a number of avenues for solving these as future work. Central to this is the longer-term study and evaluation (Remy et al., 2018) of the most promising designs to discover and alleviate these effects; we suggest collaborations with the business and regulatory communities to find the nexus between designs that balance user– and business-focused designs, with other externality costs. Given the scale, significant reach and relative lack of regulation concerning many online and digital services, it is clear that some of the more egregious social and environmental impacts will need to be addressed by HCI in any case, so we suggest moderate and meaningful design as a way forward.

CRediT authorship contribution statement

Kelly Widdicks: Conceptualization, Methodology, Validation,

Investigation, Data curation, Formal analysis, Writing – original draft, Writing – review & editing, Project administration. **Christian Remy:** Methodology, Validation, Investigation, Formal analysis, Writing – review & editing. **Oliver Bates:** Methodology, Validation, Investigation, Formal analysis, Writing – review & editing. **Adrian Friday:** Validation, Writing – review & editing, Supervision. **Mike Hazas:** Validation, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary material

Supplementary material associated with this article can be found, in the online version, at 10.1016/j.ijhcs.2022.102853

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