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Designing for Situational Visual Impairments: Supporting Early-Career Designers of Mobile Content

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ABSTRACT
Mobile devices are a substantial part of our lives, supporting communication, work, and play. However, situational visual impairments (SVIs) can make completing tasks a challenge (e.g., browsing online in bright sunlight) and poorly designed content can cause or exacerbate SVIs. We surveyed 43 mobile content designers and ran four follow-on interviews to understand what designers currently do regarding SVIs, what resources they know of, and what is required to best support them in designing to reduce SVIs. Our findings highlight key similarities and differences between accessibility and designing to reduce SVIs. Our participants requested improved guidelines, education, and digital design tools for SVIs. To accommodate the growing number of people affected by SVIs and improve the inclusion of accessibility in design, we introduce recommendations that leverage the overlap between accessibility and SVIs to minimise the effort required in extending current design processes.

ACM Classification Keywords
H.5.m. Information Interfaces & Presentation: Miscellaneous

Author Keywords
Situational impairments; accessibility; mobile content design.

INTRODUCTION
Mobile devices are appealing for their portability, while enabling us to conveniently complete many tasks. Mobile shipment sales have overtaken desktop computers [19] and US consumers spend an average of five hours per day on mobile devices [24]. Furthermore, mobile devices are also beneficial within the workplace [2, 6, 13]. However, people using mobile devices can find themselves in challenging contexts that impede usability. These problems are called *situational impairments* – a context-dependent phenomenon that poses challenges for users while carrying out a task they would normally have no difficulty completing.

Previous work in HCI has discussed situational impairments caused by the *Environment* [38], and Sears et al. [47] further identified *Application* and *Human* factors as additional contributing dimensions. As a response to this growing phenomenon, Wobbrock [53] called for a re-emphasis of mobile device research towards "on-the-go" use. There are many types of mobile device situational impairments, however, in this paper, we focus on *situational visual impairments (SVIs)* – visual impairments arising from a user's context (e.g., using Google Maps under bright sunlight) – and we investigate how to improve design processes to address this problem, since content design can cause or contribute to SVIs (Figure 1).

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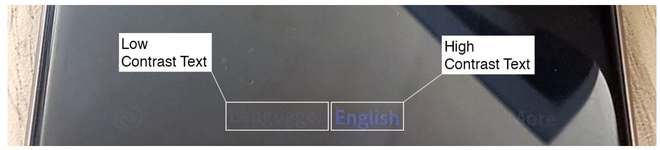

Figure 1. A smartphone in a bright environment. The low-contrast text is difficult to read, and is one example design choice that can cause SVIs.

SVIs threaten advances in mobile device use. Mobile device screens are difficult to use as ambient light intensity increases [18]. As a result, recent research has questioned the suitability of mobile devices in medical settings due to SVIs [31]. In general day-to-day use, common design choices, such as Apple's use of low-contrasting font, introduces new challenges and this has been criticised for making reading difficult for people with typical vision [39]. Support exists to help designers identify potential SVIs [15, 33], yet there are no explicit guidelines or purpose-made design tools for accommodating SVIs when designing.

We investigated what designers currently do regarding SVIs, what resources they know of, and what is required to best support them design for SVIs. We surveyed 43 designers using an online questionnaire to understand current design processes for accessibility and SVIs. Four of our survey respondents took part in a follow-on semi-structured interview, allowing us to: 1) further understand typical design processes, 2) engage in a deeper discussion regarding accessibility and SVIs, and 3) to identify effective support for designing to reduce SVIs.

Our survey indicated several similarities and differences between designing for accessibility and SVIs. Our participants reported positive connections between accessible design and designing to reduce SVIs. Both were perceived to benefit a broader set of users, and that designing for one often resulted in at least partial inclusion of the other. Reasons for not designing to reduce SVIs were: 1) it is often not in the design scope or part of the designer's current practice, 2) there are limited resources available (e.g., time, money, tools) to design for SVIs, 3) the designers are unaware or have not considered SVIs before, and 4) SVIs can be viewed as a minor issue.

Our surveyed participants recommend that existing accessibility guidelines, education, and design tools be extended to include support for designing to reduce SVIs. During the interviews, our participants recognised the value of both 'simplified' industry guidelines (e.g., Android Material Design) and more thorough guidelines (e.g., WCAG 2.0) for guiding design, as well as using the documentation for convincing clients of the necessity of accessibility. However, both types of guideline need extending to include SVIs. Future studies are required to construct SVI guidelines for mobile content. Design tools must incorporate the SVI guidelines to double as a platform that improves understanding of designing for SVIs. In addition to improving formal education, our participants emphasised targeting popular design websites (e.g., medium.com) and online self-learning courses (e.g., Udemy.com).

This paper makes three contributions. First, we present survey results from 43 designers of mobile content highlighting similarities and differences between designing for accessibility and SVIs. We found most designers are not considering SVIs and many demonstrated misunderstanding about SVIs. Second, we present a thematic analysis of follow-on interviews with four designers, used to identify how to integrate the SVI support requested by our participants. Third, we suggest how to extend guidelines and revise education, and we outline requirements for digital design tools to support designing to reduce SVIs.

BACKGROUND AND RELATED WORK

Situational Impairments, Technology and Perception

Situational impairments are a context-dependent phenomenon that make it difficult for users to complete tasks that they would usually not find difficult. Situational impairments are known within HCI [38] and result from many factors [47]. Recently, Mauderer et al. [35] discussed moving beyond accessibility to address perceptual limitations experienced by everybody. Focusing on supporting all people is an approach also promoted by Universal Design [9] and Universal Usability [51].

There are many types of situational impairments, for example, research has investigated the challenges walking can have on being able to read text on a mobile phone [37] and how some input errors on small devices compare with errors from people with a motor impairment using a desktop [57]. There have been investigations into solutions for mobile device text entry and interaction while walking [17, 23]. Yeilsada, Brajnik and Harper [54] found commonalities between accessibility issues for people with low vision and people using a mobile device.

In this paper we focus on *situational visual impairments (SVIs)* and how design can be utilised to address this problem. The typical transmissive displays used in mobile devices require a backlight to display content on the screen [7]. Increasing ambient light reduces the image quality on the display [26, 25, 30] and the issue remains with newer screen technology, such as IPS and AMOLED displays [18]. Although anti-glare layers help, they can degrade image quality [40] and cause users to experience "visual sparkle", which is a perceived glittering effect on the display [8]. Improvements have been utilised to brighten screens (e.g., One Glass Solution [20]) and some Nokia devices use ClearBlack Displays [16], which have polarising layers under the screen to block ambient light. Yet, focusing on ambient light levels only addresses one cause of SVIs. If screen brightness is reduced to conserve power, a similar problem to viewing a screen in a bright environment occurs. Sarsenbayeva et al. [46] indicates there is limited research looking into ambient light SVIs and suggests auto-brightness may be why few studies on SVIs exist. More research is required to fully understand the factors involved and the frequency of experiencing SVIs.

Reinecke et al. [45] and Huang et al. [22] both demonstrate variations in people's perceptions under different lighting. Using ~30k web participants, Reinecke et al. found that both increasing ambient brightness and decreasing monitor brightness reduce colour differentiation abilities. Huang et al. used a smaller sample to look at visual comfort when reading on a mobile device. Higher contrasts were preferred by older participants, and female participants (particularly young female participants) preferred less contrast.

Current Support For Designers

Designers can employ a more inclusive approach to design by considering potential SVIs that a user might experience.

The W3C website includes a page called "Shared Web Experiences: Barriers Common to Mobile Device Users and People with Disabilities" [56] that lists examples of how accessibility issues such as the use of colour and font size can also be a problem for all mobile users without disabilities.

The current version (29th July 2008) of the Mobile Web Best Practice (1.0) [44] aims to improve Web browsing user experience on a mobile device. For checking colour contrast, the human test recommends shining a strong light on the screen of the mobile device while browsing the page. Instead, it may be better to develop a tool that is similar to ColorCheck [45], which supports designers by highlighting how their colour choices are difficult to distinguish for different proportions of the population. Using an automatic tool would meet the Mobile Web Best Practice machine test recommendation and to our knowledge no purpose-made SVI design tool currently exists for this to be achieved. The Mobile Web Best Practice document is now ten years old and mobile technology has changed. In addition to issues with suggested contrast ratios, it does not give sufficient SVI support regarding font style or what to consider when designing icons.

Furthermore, a working draft paper by the W3C highlights how current accessibility guidelines apply to mobile [41]. It draws attention to the issue that mobile devices are used in a range of lighting situations that can reduce usability – something not explicitly addressed in WCAG 1.0 [14] or 2.0 [12]. A limitation of the working draft is that the suggested contrast guidelines are based on calculations from WCAG 2.0, which were calculated for desktop only [41]. Although WCAG warns of the limitation, a designer is left to decide how best to proceed, which is concerning for mobile app design because the iOS [4], Android [3], and Universal Windows Platform [36] design guidelines suggest using WCAG 2.0 contrast ratios.

In addition to guidelines, there are also design toolkits to be used as part of the design process to help designers consider user behaviour in different settings [15, 33]. A workbook by HaptiMap [33] motivates designers to think about the many situations in which a user may find themselves using a system. There are also accompanying 'context cards' that have a variety of context and environmental prompts (e.g., 'pushing a stroller', 'bright light') that are used to help designers think about the implications of those conditions. 'Inclusive: A Microsoft Design Toolkit' (microsoft.com/en-us/design/inclusive) serves a similar purpose. However, these toolkits do not provide specific guidelines to help designers make informed decisions about how to reduce SVIs.

Current resources may not suitably support designers in designing to reduce SVIs. We do not know what designers currently do regarding SVIs, what resources they know of, and what is required to best support them in designing for SVIs. To gather this information, we distributed an online questionnaire.

ONLINE QUESTIONNAIRE

Material and Procedure

Our questionnaire (provided in supplementary materials) comprised of 22 close-ended and 16 open-ended questions. We distributed the questionnaire among Scottish universities and design companies, and for a wider audience used social media (e.g., Facebook, Twitter), Reddit's r/samplesize, r/designthought, and r/UI_Design; asking for designers who have released mobile content publicly or commercially.

As per our REB approval, participants first read through an information page and consented to taking part. The questionnaire was expected to take five to ten minutes to complete depending on the responses given. After submitting, the participants were debriefed and could enter into a prize draw for one of four $50 USD (or equivalent) Amazon vouchers.

Participants

Forty-four participants completed our questionnaire. One participant was removed from the analysis because he did not design any mobile content. The remaining 32 male and 11 female participants were aged 18 to 52 (Mean = 27.15, SD = 7.18; three did not respond). Twenty-two participants (51.16%) were living in the UK, with 48.84% living outside the UK (11 in the US, three in Canada, two in India, and one in Senegal, The Netherlands, Turkey, Philippines, and Australia).

Our participants indicated that they had varied design training backgrounds (multiple responses were allowed): 'Undergraduate level university' (23 participants), 'No formal training' (10), 'College' (8), 'Apprenticeship' (8), 'Postgraduate level university' (8), and 'Other' (2 – P11 wrote "*personal projects*", P21 wrote "*general assembly (the education startup)*").

We asked our participants what best described their design career; 24 participants said 'Working for a company', followed by 'Self-employed' (8), 'Hobby' (8), 'Other' (3 – "*Design researcher and practising Architect*" (P1), "*Designed as part of coursework*" (P8), "*Company owner*" (P13)).

Our participants created a range of mobile content (28 participants designed more than one type of content); our participants reported 'Mobile friendly websites' (32), 'Mobile apps' (26), 'Advertising' (12), 'Games' (7), 'Books' (5), and 'Other' (4 – "*data UI/UX*" (P2), "*brand identity*" (P32), "*branding, video graphics, magazines*" (P41), and "*Logo & Branding*" (P43)).

We asked how many years the participants had publicly or commercially released mobile content and found 42 participants had up to 15 years of experience (M = 3.71, SD = 3.64, Median = 2). Indicating that our sample is predominately made up of designers early in their design careers.

Results

Accessibility

We first asked accessibility questions to check that our sample are representative of those previously reported in the literature.

The participants were provided with a brief definition of accessibility taken from Henry et al. [21] "'*Accessibility' has historically referred to design that enables people with disabilities to interact with buildings, products, services, etc.*" and asked if they include accessibility in their design process. The responses were: 'Always' (13), 'Sometimes' (24), and 'Never' (6). For the 24 participants who indicated 'Sometimes', two-thirds only include accessibility in 40% or few projects. Overall, the proportion of our participants who include accessibility in any or all of their designs (~86%) is somewhat higher than in previous research (75%) [50], which could be due to the different recruitment mechanisms and our study focusing on mobile content designers.

Our participants who 'Always' and 'Sometimes' include accessibility typically do this 'From the beginning' (13 participants) and 'During the process' (19), while some only included accessibility 'When a design is complete' (5). We found that guidelines (e.g., WCAG) were used by 27 participants, accessibility-focused design tools (e.g., WAVE: wave.webaim.org) were used by 19 participants, and accessibility user evaluations were carried out by 14 participants. Among the types of user evaluations reported, there was evidence of evaluating without impairment (e.g., P18: "*Best guess. We do not have people come in to test it*"), recruiting people (e.g., P21: "*User testing with users who are sight-impaired for TTS*"), and evaluating with design tools (e.g., P30: "*With the use of site's like colorhexa.com*"). The six participants who never include accessibility were aware of at least one of the following: accessibility guidelines (four participants), accessibility design tools (2), and accessibility evaluation techniques (4).

We were also interested in why designers do or do not include accessibility to identify any overlaps between accessibility and SVIs. The reasons given **for** including accessibility are combined responses from participants who 'Always' or 'Sometimes' include accessibility. These reasons were: there is a moral obligation (16 participants), it was a requirement of the project (10), it improves the usability and UX (6), there is a recognised value in accessibility (3), a legal obligation (2), time was available (2), it does not require much effort (2), and pushing for accessibility will change perceptions (1). The reasons given **for not** including accessibility are combined responses from participants who 'Sometimes' or 'Never' include accessibility. These reasons were: limited resources

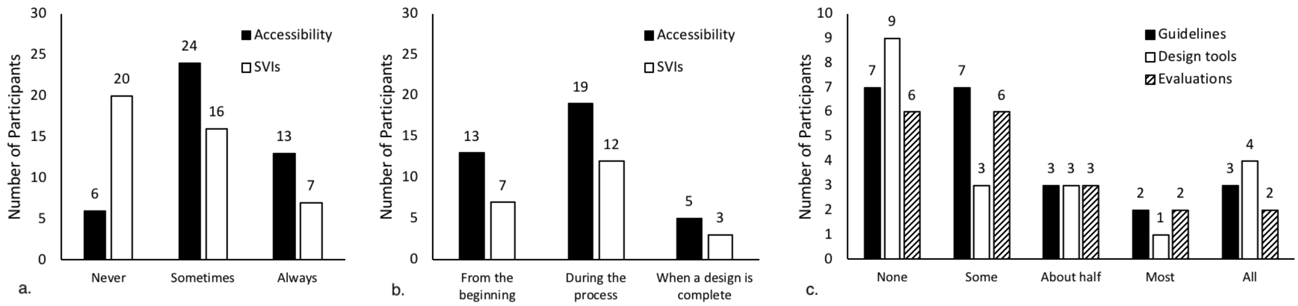

Figure 2. A) A summary of how many participants include accessibility and design to reduce SVIs. B) A summary of when accessibility and SVIs are part of the design process. C) A summary of how many participants use guidelines, design tools, and evaluations to reduce SVIs from occurring.

(e.g., time, money) (14 participants), it is not within the scope of the project (10), accessibility restricts design (2), achieving 100% is challenging (2), disinterest in accessibility (1), unpopular with management (1), and personal preference (1).

Situational Visual Impairment

We provided our participants with the definition "*situational impairments are usually caused by environment conditions that negatively affect a person's ability to complete a task when they would otherwise not have a problem*" and listed three examples: 1) standing in a noisy crowd on the phone (situational hearing impairment), 2) carrying shopping bags and trying to compose an SMS (situational mobility impairment), and 3) wearing glasses with coloured lenses, while trying to identify colours on a screen (situational visual impairment). We only provided a few examples to help reduce biasing participants. We asked if our participants design to reduce situational impairments to lead into focusing on SVIs.

We first asked our participants if they design to reduce SVIs. All forty-three participants responded to this question with 'Always' (7), 'Sometimes' (16), and 'Never' (20). There is a noticeable change (see Figure 2a) in distribution compared to the counterpart accessibility question – SVIs are not considered by the majority of the participants. A McNemar-Bowker test indicates a significant difference ($p = .007$) between the distributions. Bonferroni corrected post-hoc tests identified a significant difference between 'Never' and 'Sometimes' ($p = .024$).

For the 16 participants who sometimes design to reduce SVIs, we wanted to see how often this occurs in their design projects. Responses were: 'Rarely (Less than 20%)' (7 participants), 'Occasionally (20-40%)' (6), 'About half (40-60%)' (2), and 'Often (60-80%)' (1). A similar decreasing trend was also present in the counterpart accessibility question.

We asked our participants what types of SVIs they try to reduce occurring through design. Sixteen participants responded but only six participants listed genuine causes for SVIs such as reading at night, unusual interior/exterior lighting, bright situations, wearing tinted glasses, being far from a screen, being in a moving vehicle. Four mentions of colour vision deficiency demonstrated potential misunderstandings of SVIs.

Twenty-two participants told us the earliest point at which they design for SVIs: 'From the beginning' (7 participants), 'During the process' (12), and 'When a design is complete' (3). This distribution is similar to the counterpart accessibility question (see Figure 2b). Most participants consider accessibility and SVI 'during the process', suggesting a fluid design approach rather than focusing on all details from the outset.

Twenty-two participants told us what proportion of projects used SVI guidelines: 'None' (7 participants), 'Some' (7), 'About half' (3), 'Most' (2), and 'All' (3) (see Figure 2c). Out of seven responses to the follow-on question there were no mentions of guidelines that highlight the issue of SVIs (such as "Shared Web Experiences" [56] and Mobile Accessibility [41]) – P19 said "*can't find any*", while P4 and P41 mentioned colour vision deficiency (CVD), thus providing further evidence that designers misunderstand SVIs. P29 responded "*clear and large fonts*", which is likely to be easier to see when in a bright environment, however it is not clear what guideline this idea originates or if the designer has determined this on their own.

Twenty participants told us what proportion of projects used SVI design tools: 'None' (9 participants), 'Some' (3), 'About half' (3), 'Most' (1), and 'All' (4) (see Figure 2c). Out of five responses listing tools, there were three mentions of tools for CVD. Either this is a misunderstanding or they are using CVD tools because no alternatives exist. One comment was "*N/A*" (P40) and the other was "*Color contrast buttons*" (P6).

Nineteen participants told us what proportion of projects ran evaluations with people experiencing SVIs. 'None' (6 participants), 'Some' (6), 'About half' (3), 'Most' (2), and 'All' (2) (see Figure 2c). Out of 12 follow-on requests to list evaluation techniques, there was a range of approaches. We found four mentions of self-testing, four mentions of in-house testing, two mentions of external testing, one mention of simulating the environment, and three other mentions related to: 'user testing environments', 'usability test', and 'direct observation'.

What reasons were given ***for*** *designing to reduce situational visual impairments?* We combined responses from the participants who said they 'Always' or 'Sometimes' design to reduce SVIs. Reasons given were: benefits everybody (8), for improved accessibility (3), project requirement (2), sufficient budget and time (2), for completeness (1), and moral obligation (1). We found that there are some similarities and differences between designing to reduce SVIs and including accessibility. Moral obligation, requirement of project, and having time were present in both. Having a sufficient budget was mentioned as a reason for designing to reduce SVIs, but it was not mentioned as a reason for including accessibility, although budget was listed as a reason for not including accessibility. There was no mention of a legal obligation, but, this is unsurprising since we are unaware of any laws for situational impairment. Discussion of designing to reduce SVIs benefiting everybody, for completeness, and improving accessibility, are similar to the 'improving usability and UX' reasons given for why designers include accessibility. Interestingly, while one participant said that pushing for accessibility will change perception, this did not occur for SVIs and is likely due to situational impairments not being widely discussed or understood. The fact that everyone is affected by SVIs could be used to positively change perceptions.

*What reasons were given **for not** designing to reduce situational visual impairments?* We combined responses from the participants who said they 'Sometimes' or 'Never' design to reduce SVIs: it is not in the design scope or their current practice (13 participants), limited resources (e.g., time, tools, money) (13), the participants are unaware of or had not considered SVI (5), and SVI is viewed as a minor issue (4). There are some similarities and differences between not designing to reduce SVIs and not including accessibility. Not within the project scope and limited resources were present in both. However, the responses for not designing to reduce SVIs also pointed towards it not being a part of current practice, which means we need to find ways to ensure that designers do adopt this in their design process. Differences in responses further highlight the uncertainty about SVIs and situational impairments in general. SVIs being viewed as a minor issue echo some of the opinions presented about accessibility (P17: "*It is not usually considered a priority due to the [percentage] of people it would affect*"), however, this is not the case with accessibility when considered on a global scale, and with the increase in mobile device use we expect SVIs to be increasingly prevalent. Several participants stated they were unaware of or had not previously considered SVIs, highlighting the need to investigate how this is approached during education. The remaining responses for not including accessibility were the challenges (e.g., it restricts design), the disinterest in accessibility, and the personal preference of not including accessibility; these could equally apply to SVIs. In fact, we asked the participants to tell us if they distinguish between a visual impairment and a situational visual impairment and seven participants indicated 'Yes', five indicated 'No', and P19 responded "*yes and no*". This further underlines the perceived similarities and differences between accessibility and SVIs.

Finally, we wanted to know what would best help designers create content less susceptible to SVIs. All the participants responded and were allowed to indicate more than one response. In order of most requested: 30 participants wanted 'Guidelines', followed by 'Education' (25), 'Digital design tools' (20), 'Support service' (13), 'Physical design tools' (9), and P42 said: "*Understanding the context of use. That is always the biggest hurdle. After that, design becomes a lot easier.*"

Summary

Our results illustrate similarities and differences between accessibility and SVIs, and was integral in providing us with information regarding current practice and the type of support designers want. We conducted follow-on interviews to identify how SVIs are handled in design (if at all) and how to effectively integrate SVI support into design processes.

INTERVIEWS

We conducted follow-on semi-structured interviews: 1) to further understand typical design processes, 2) to have a more in-depth discussion regarding accessibility and SVIs, and 3) to identify effective support for designing to reduce SVIs.

Method

The interviews were semi-structured using an interview guide (supplementary materials), with two occurring over Skype. The interviews were audio recorded for later transcription. The shortest interview was 38 minutes and the longest interview was 1 hour (M = 50 minutes). The participants were reimbursed with a £10 GBP (or equivalent) Amazon voucher.

Participants

Twenty participants from the questionnaire provided their contact details so we could invite them to the follow-on study. When contacted, four participants consented to take part in an interview (Table 1 summarises their backgrounds). All the participants reported experiencing SVIs. However, when it comes to designing to reduce SVIs, Max does not usually consider SVIs. Jo sometimes considers SVIs, especially if time permits, while Ron is always considering SVIs. Ann has worked on a project where an SVI feature was implemented. Since taking part in the questionnaire, there were no reported changes in considering SVIs during their design process.

Phases of Thematic Analysis

We closely followed the six phases of thematic analysis, as outlined by Braun and Clark [10]. First the audio recordings were listened to in full, then transcribed, anonymising places and names as we went. The transcripts (in supplementary materials) were checked against the audio recordings to ensure accuracy. RQDA (rqda.r-forge.r-project.org) was used to support the process of thematic analysis (e.g., the coding of interesting features). We provide the initial thematic map in supplementary materials. We reviewed and removed themes that did not reflect the aims for this study, and further refined the thematic map. This refinement was done with a Level 1 analysis (each code was discussed in relation to the thematic map) and a Level 2 analysis (checking that the themes suit the entire data set). Inter-rater reliability did not take place because it is not part of Braun and Clark's recommended process for thematic analysis, and there is debate as to whether it is suitable for this type of research approach [5, 34]. The completed thematic map is shown in Figure 3.

Results

Discussion on accessibility is prominent because SVIs are not something some of our participants often include when designing. We let our participants reflect on accessibility to learn how to support their practice. We found three themes (with nine sub-themes): *Design Practices Will Vary*, *Achieving Accessibility is Complex*, and *One Solution Does Not Fit All*.

ID	Age	Gender	Experience and Education
Jo (P3)	23	F	*Jo has been releasing mobile content for 1.5 years*. She has an Environmental Engineering undergraduate degree. She is currently undertaking a Masters degree and has taken part in workshops run by app developers and self-learns (e.g., using Coursera.org).
Max (P17)	28	M	*Max has been releasing mobile content for 2-3 years*. He has an Applied Computing undergraduate degree and is a games designer with no formal training – he describes it as a "*learn as we go*" job. The company creates their own games and perceives the customer as the client.
Ann (P19)	26	F	*Ann has been releasing mobile content for 2.5 years*. She has an Applied Computing undergraduate degree and a MSc in User Experience Design. She is employed as a mobile designer making native apps and hybrid apps (i.e., applications built with Web technologies to run on multiple platforms).
Ron (P30)	19	M	*Ron has been releasing mobile content for 3 years*. He had previously attended a design school and at the time of the interview had a few weeks left of his degree at a different school in the Netherlands. He was also working at a company as an intern designer.

Table 1. Participant demographics with descriptions of education, training, and work experiences. Each participant has been assigned a pseudonym.

Design Practices Will Vary

Our participants discussed their general design practices and, predictably, design does not have a one-size-fits-all approach. The design approaches can be adaptive, iterative, and unstructured. Some treat guidelines as suggestions rather than following them precisely. Being able to work quickly and efficiently is important to our participants, who recognised that involving more people in a design process can be detrimental. Within this main theme there were four important sub-themes.

Challenges of Client Involvement

Several different challenges were highlighted across participants with regards to dealing with clients throughout the design process. Client involvement can be a positive thing and participants viewed it as important, however, it was evident that there are negative experiences too.

> Ron: "*I've spent hours [with] clients [who] have just pointed...'I want that to move one pixel to the right, I want it to move one pixel.' It was really one pixel!*"

In general, the challenges faced were often because the design brief was incorrect (e.g., not making requirements clear).

> Ron: "*That's most of the time I think [the design brief] is missing something.*"

Clients can also have a negative attitude towards accessibility, often not requesting the inclusion of accessibility.

> Ann: "*A lot of clients think that [accessibility] takes longer for us to do and no-one is going to use it.*"

Clients may have brand colours that are problematic from an accessibility point of view. When designers raise accessibility concerns, the client can become distrustful and overbearing, often needing convincing about why certain requests are not suitable for the product. When designers want to design to reduce SVIs, clients may react in a similar way, but unlike when focusing on disability, designers can make a strong argument reasoning that *all* users can experience SVIs.

Perceptions of Design Guidelines

The participants discussed various positive and negative opinions regarding design guidelines. In general, guidelines help designers with a starting point for good design. Recent design guidelines, such as Google's Material Design and Apple's iOS design guidelines are perceived as being well suited. There is also trust in guidelines because they are understood to be vetted by others over time:

> Jo: "*I think that nowadays there are the guidelines when designing and you should follow them because [the guidelines are] something proven.*"

Guidelines that are associated with a well-known or large company (e.g., Apple) are used to discourage clients' poor or inaccessible design suggestions. Such guidelines are also appealing because they are often written using less technical language compared to other guidelines (e.g., WCAG). However, guidelines are not always seen as a positive resource. Guidelines can contain far too much content. At a minimum, designers want to find the key points quickly:

> Ann: "*Have you seen the meme of...the big JavaScript book? And then it's like JavaScript the good parts...the guidelines need that!*"

There is also the risk that guidelines can be distrusted if they are not written in a way that is expected by designers:

> Ann: "*We don't link anyone to WCAG because it doesn't look...trustable. They need to be completely rewritten, not like changed but just, there's so much needless text!*"

Approaches to Evaluating

Our participants discussed their opinions of feedback on design and their different evaluation approaches.

Two designers (Max and Ann) recognised the importance of evaluating a design early, with Max elaborating that user feedback is useful because usability issues can be identified early. In addition, Jo spoke about the importance of evaluating with a diverse group of people.

Evaluating with people is viewed as important, but sometimes the people used for those evaluations are not the target audience. Participants mentioned evaluating with the intended user group (Max), but also staff (Max) and students (Jo).

It is possible to run evaluations for SVIs. Sometimes designers are unable to evaluate under real-world conditions and so need

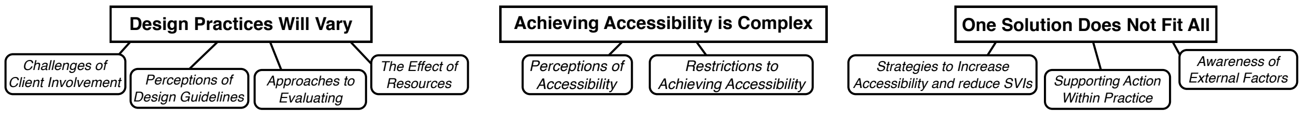

Figure 3. The thematic map with the final themes (*Design Practices Will Vary*, *Achieving Accessibility is Complex*, and *One Solution Does Not Fit All*).

to get creative. Jo and Ann discussed altering the environment to conduct evaluations:

> Jo: "*We changed the parameters like [room] lighting, and stuff like that.*"
>
> Ann: "*[We] tested it by shining [flashlights] on the phone to see if it worked because it wasn't sunny outside so – (Ann laughs) – there wasn't a lot we could do.*"

While this is commendable, providing clear SVI guidelines would increase the designers confidence that they are creating the best designs to reduce the occurrence of an SVI.

The Effect of Resources

Our participants also discussed the ways in which available resources (e.g., guidelines, time, money) can affect design.

Sometimes our participants will use design tools and they are positive towards these. For example, using a design tool that simulates colour vision deficiency helps show why designers need to consider colour more carefully (Ron). A tool that can do this for SVIs would support the designer, while increasing awareness of any nuances SVIs have in a similar way that there are different types of colour vision deficiency [48].

There was evidence of our participants trusting particular resources. For example, academic research findings that inform good design practice and trusting default designs from major OS platforms (e.g., fonts) because they will have been sufficiently verified and so save the designer time. There was uncertainty among all four participants as to the existence of guidelines for SVIs and Ron was unsure of the content of the accessibility section to Google's Material Design documentation. We know that some guidelines highlight SVIs (e.g., "Shared Web Experiences" [56] and Mobile Accessibility [41]), and the participants not mentioning this suggests that they need to be promoted more, however, based on Ron's point it is also important that guidelines be designed in a way for more rapid comprehension as discussed in the *Perceptions of Design Guidelines* sub-theme (above).

Finally, a lack of resources (e.g., time, budget) affected all of our participants. Jo mentioned facing a lack of resources and explained that "*One perception was to do it for free or not do it at all, so we preferred not to do it at all.*" In game development, Max said that a game never truly ships in a finished state because there is "*always more stuff*" to do.

Achieving Accessibility is Complex

Jo, Ann, and Ron all include or have included accessibility in their design process. All our participants were familiar with accessibility, but the amount of focus given to accessibility varied. Max and Ann had similar, quite extensive exposure to accessibility through their undergraduate degrees. However, while Ann includes accessibility during work, Max does not, highlighting how different industries can dictate accessibility adoption. Max does believe it "*would be nice to do*".

Perceptions of Accessibility

There are similar and contrasting perceptions that our participants presented towards accessibility, as well as their positive and negative attitudes towards accessibility.

The perceptions of accessibility range from negative to positive. During the discussion with Ann and Ron, there was a sense that accessibility is an afterthought for some designers. The negative perceptions towards accessibility that were offered as reasons for it not being done was that it took time to implement and it only benefits a small number of people – suggesting great effort required (in time and money) for little reward. Furthermore, requirements of implementing accessibility were seen as compromising design. The positive perceptions of accessibility were that it was not only important for people with disabilities but for all users because they benefit from accessibility (Jo and Ann). Ann also commented that because accessibility improves usability and user experience it would increase the likelihood of people returning to a product.

Similar contrasting views were present when commenting on SVIs. Jo said, "*No, it's not a small issue at all. [Using] an application [on] your mobile phone...you're not at home [in a controlled environment]...you go everywhere.*" However, Max did not consider it to be an important problem.

Restrictions to Achieving Accessibility

Our participants emphasised several reasons for designers not including accessibility when designing, which can provide insights into issues for promoting the consideration of SVIs.

Accessibility within education can vary. Two of our participants (Max and Ann) found there was a major focus on accessibility within their education, while Ron said accessibility was only given a minor focus, if any at all. Jo was introduced to accessibility, but it is unclear how much focus it was given. Restrictions to achieving accessibility may be due to designers themselves having a lack of awareness, particularly if they are early in their design career and therefore are unsure how to go about designing accessible content. Their lack of knowledge means it does not get done:

> Ann: "*They've come from being a pure graphics designer and moved in, and there's a lot of considerations that they just don't have.*"

In addition, limited exposure to accessibility is not limited to formal education; online courses, for example online UX courses "*barely mention accessibilty*" (Ann).

Max suggested that accessibility would be included if it was requested by the game players, thus reasoning his games do not require accessibility because there is no demand. However, by offering an inaccessible gaming experience, the players that require accessibility could be looking elsewhere. It is estimated that in the US alone, 6.2 million people are unable to play games due to a disability [61]. Max also suggested that the function of a product can determine if accessibility should be considered, believing that "*accommodat[ing] a lot of accessibility options in games kind of compromises, well it can compromise the actual gameplay.*"

There is also the problem that current accessibility solutions are not adequate to support accessible design:

> Ann: "*I think a lot of the limitations of them is that they're terribly designed – (Ann laughs).*"

To ensure adoption of any solutions, such as design tools for SVIs, development must closely involve input from designers.

One Solution Does Not Fit All

There are different ways in which the inclusion of accessibility and designing to reduce SVIs can be increased. We report what support is required and the need to raise awareness about other factors that contribute to SVIs.

Strategies to Increase Accessibility and reduce SVIs

Our participants discussed ways in which awareness and understanding of accessibility and SVIs can be increased. It is clear that talking about these problems is not enough:

> Jo: "*There is no point of talking and talking about an issue without doing anything, [give designers] something because designers want to have something.*"

Time was a recurring theme; designers require strategies that will save them time by supporting quick accessible design. Furthermore, considering the budget constraints faced by designers, any solution must be affordable (preferably free). There should be effort among the design community to create a dialogue discussing SVIs and accessibility in general:

> Jo: "*I think that we should, actually, all of us, we should try and make [designers] understand.*"

Although Max equates education as similar to what guidelines are doing, educational settings can be used to scaffold the learning process of why guidelines are important and how they can be used. Since SVIs are "*never mentioned*" (Ron), it is important to target education and run tutorials or workshops, because learning extends beyond formal education.

It is also important to disseminate research outside of academia to increase awareness and understanding (e.g., Ron suggested a marketing campaign), and increase presence on popular websites used by designers. Ann felt that inclusion of a case study would be helpful. Since major OS platforms have some influence on designers, it was recommended that change could occur if the OS companies push for designing to reduce SVIs. Max mentioned that one way to increase accessibility within the games industry is for the app store companies (i.e., Apple and Google) to "*push for [accessibility]*" by saying a game can only be featured or promoted if it is accessible.

Finally, for some designers they may only be willing to rely on automated solutions handed by the mobile device. Max spoke positively about "*[Getting] saved a lot by the OS you know, like that colourblind mode and things like that.*"

Supporting Action Within Practice

There are different ways that we can help designers implement accessibility and, in particular, design to reduce SVIs. Evaluations with people are important, however, recruiting people can be difficult. Jo suggests using incentives for getting people to take part, although this can become costly. It is important that the guidelines are *easy to understand* by the designer, but also for the client because designers are able to use design guidelines as leverage when the client is adamant that the design must meet a particular request. However, it is important that the solutions offered do not restrict design too much. We could achieve this with flexible guidelines to help maintain the designer's creativity:

> Max: "*As long as they weren't too restrictive then we'd probably be quite happy to just do that all the time.*"

Offering design tools will be helpful and can reduce the reliance of reading guidelines. Max and Ann both felt that simulations would be useful to enhance the designer's understanding of SVIs, and simulations can be incorporated into design tools. However, a design tool must fit within the design process. This is a challenge since we know that designers do not follow the same design process, and even for an individual designer, approaches can vary according to the project requirements:

> Ann: "*I think that a lot of [the accessibility tools] are very much designed for specific use cases...but as part of a design flow, it sits by itself and it's very isolated.*"

This presents an interesting challenge where there is a need for adaptable accessibility and SVI design tools that meet the needs for many different designers and their projects.

Finally, various techniques were discussed by our participants throughout the interview, either when discussing accessibility for visual impairments or SVIs, and these can be used to improve content visibility overall: increase brightness, increase contrast, increase font size or zoom in to the content, increase line thickness and weight of an element. Although guidelines exist for accessibility, we need to investigate what contrast ratios and font size are appropriate for SVIs. Jo suggested that applications should adapt to the environment.

Awareness of External Factors

There are also external factors that designers should be considering so that alternative modes of interaction can be implemented. One participant raised the point that external factors contribute to situational impairments:

> Ann: "*If [a user is] outside, there's a couple more things we need to be looking at, things like: Can they actually see it? Are they gonna be wearing gloves? [Will they] be touching the screen?*"

Although the full set of factors that contribute to SVIs is currently unknown, any solution must be flexible both in terms of design process and its outcome. Using resources such as the Haptimap Context Cards [33] are a good starting point, although they do not easily lend themselves to solutions.

DISCUSSION

Through surveying designers we found that there are striking similarities between the challenges faced when designing for accessibility and for SVIs – particularly when considering past issues surrounding accessibility. It appears as though SVI design is understandably 'behind' accessibility design: designing to reduce SVIs is often not in the design scope or part of the designer's current practice, there are limited resources available (e.g., time, money, tools) to design for SVIs, some designers are unaware or have not considered SVIs before, and SVIs can be viewed as a minor issue. However, our participants also reported positive connections between accessibility and SVI design. Both were perceived to be of benefit for a broader set of users than the target audience, and it was recognised that designing for one often resulted in at least partial inclusion of the other.

Our participants reported a *legal* obligation to incorporate accessibility in their designs, whereas this was not evident when discussing SVIs. Instead, motivation can come from *financial* gain through increasing market share by considering SVIs because people are more likely to return to apps with increased usability in different contexts. Furthermore, our participants incorporate accessibility due to moral convictions, suggesting a sense of *sympathy* for users with disabilities and arguing it is unethical to exclude accessibility. Impairment simulations can help designers build understanding of the importance of accessibility both in education [59] and a broader context [32], but these can be difficult, expensive, or time-consuming to prepare. In contrast, consideration of SVIs is likely coming from a feeling of *empathy* because designers, having experienced SVIs, can relate more easily. The 'empathic' understanding designers have of SVIs can be leveraged to enhance awareness of the importance for SVIs and accessibility, which should help to increase the inclusiveness of design. In our recommendations section for education, we further discuss increasing inclusivity and accessibility through designing to reduce SVIs in the context of related literature.

Compared to accessibility, less is known about particular situational impairments, such as SVIs, and what design guidelines are required [46]. Previous work has demonstrated the limitations imposed by hardware (e.g., screen technology [18]). Better displays and using auto-brightness only partially address the problem. More research is required to understand all the factors involved when experiencing SVIs. It is important to investigate how users currently deal with SVIs, which may result in alternative solutions not yet considered. However, we know that design can both cause and exacerbate SVIs.

Overall, there were fewer designers considering SVIs than accessibility. In addition, some participant responses showed a misunderstanding of what SVIs are, likely artificially inflating the numbers of designers who reported that they feel they are designing to reduce SVIs. Our participants requested support in the form of 'Guidelines', 'Education', and 'Digital Design Tools' and we ran follow-up interviews to identify the best way to integrate this support within current design processes.

From our interviews, we identified three themes providing us with greater insight into supporting designers in designing to reduce SVIs. The themes were *design practices will vary*, *achieving accessibility is complex*, and *one solution does not fit all*. In light of our findings, we next discuss and make recommendations on how to extend each of the following: Guidelines, Education, and Digital Design Tools.

Recommendations

Guidelines – We recommend that existing accessibility guidelines be extended to include SVIs. Industry guidelines (e.g., Android Material Design (material.io/guidelines) and WCAG 2.0 [12]) should be extended to help designers to increase luminance contrast for reduced screen brightness (e.g., due to low-battery) or bright sunlight situations. Huang et al. [22] have made progress in outlining mobile interface guidelines for comfortable reading, however, their study was run in a controlled indoor environment with ambient illumination levels much lower than those expected outside [1], thus further research is required. It is important to revise contrast ratios with data gathered on a large scale from typical real-world conditions and investigate guidelines for design elements such as font type, style, size, and weight, as well as icon designs.

Through discussion during the interviews, it became clear that there are both positive and negative attitudes towards guidelines. Criticism about accessibility guidelines (e.g., WCAG) being too verbose and dense is not new [11, 49], however we did discover that there are also positive attitudes towards guidelines (e.g., using them to support an argument against a client's design request, trusting the content designed will be of a high standard). Ultimately, we must create guidelines that are easy to understand and allow for a degree of flexibility (Ann: "*...a number but with a tolerance level...*") so creativity is not restricted. Allowing for flexibility is important: P15 (questionnaire) reported "*often picking colors is limited*", and during the interview Ann discussed the challenge of having to use company brand colours (echoing previous research [50]).

Education – During the interviews, Ron explicitly said SVIs were not part of his education and the other three participants discussed ways of increasing awareness and understanding of SVIs without mentioning their own education.

Youngblood et al. [58] argue that the ethical reasons for implementing accessibility are not effective, and so more should be done to emphasise the legal implications of not creating accessible content. However, as we found in our study, legality does not factor into designing to reduce SVIs at all because it is not required by law. Instead, we could potentially further increase the motivation to include accessibility by arguing that the population affected by SVIs is much larger and broader. This approach is not new; both Universal Design [9] and Universal Usability [51] promote designing for a broad range of users and situations. This idea persists in the academic community – a panel discussion led by Gavin Lew suggests that addressing accessibility for people with a disability will lead to designs that are universally beneficial [28]. This opinion is also supported by Petrie et al. [42] and Yesilada et al. [55]. However, based on the results of our study, it seems that this knowledge is not being passed on to designers.

There has been research looking at the pedagogical culture for accessibility in computer science programs [29], and suggestions on how to instil best practice in higher education classrooms [43, 58]. However, in addition to formal education, other methods of design training were discussed such as using online courses and learning best practice approaches promoted at conferences. Our participants discussed a range of resources available for people to learn from (e.g., online courses such as Coursera.org and Udemy.com, case studies on medium.com, blogs). In addition to formal education, targeting design websites (e.g. dribbble.com, medium.com) and online self-learning courses to address SVIs can further raise awareness and help to forge an inclusive design culture.

SVIs provide the benefit of helping designers to *empathise* first, rather than be *sympathetic*. Leveraging the conceptual and practical overlap between accessibility and SVIs, this empathy can increase accessible design. However, it is important to recognise that situational impairments are a temporary experience, therefore we must be careful not to equate situational impairments with congenital and acquired disabilities as they are fundamentally different [21].

Digital Design Tools – Digital design tools are one method of supporting action in practice, and this was the third most requested solution to support designing to reduce SVIs. A design support tool can serve as a platform for understanding how best to design for SVIs and the tool should incorporate the extended guidelines we suggest above.

Max discussed being more willing to rely on automated accessibility options provided by the mobile device's OS, thereby reducing the responsibility of the designer to create accessible content. Jo discussed applications that can adapt to the environment. Adapting content under variable lighting has been researched before [27, 60, 52]. However, this passes the responsibility to either the user to install an app, or the manufacturer or OS creators to implement the setting on the device. By automating the feature, there is additional processing power (resulting in lower battery life) and, more importantly, the designer no longer has control over their design's look.

During our interviews, Ann explained that accessibility design tools tend to be inadequate either by not fitting within the designer's design process or needing to be used when a design has been finished, thereby making accessibility checking more of an afterthought. Tigwell et al. [50] found similar issues with online tools for supporting designers to choose accessible colours for people with colour vision deficiency, yet demonstrated that by including designers in the creation of such tools, focus can be placed on designing with accessibility in mind, rather than restricting creativity for accessibility. SVI design tools must be developed with a user-centred design approach.

Our participants discussed increasing contrast to reduce SVIs caused by bright environments. In particular, Ann discussed implementing a high-contrast version of an interface, however, this addition was late in the design process and was only achieved because her design team had time while another feature was being developed. Considering that common issues reported by the participants were *working towards a deadline* and *not having enough time*, the design tool should support rapid designing, and be implemented to fit within the designer's typical work environment. The benefit of this approach is that the designer has control over the look and feel of the high-contrast design. Furthermore, it would be beneficial if the design tool allowed designers to interact with the interface layout to alter other design elements (icons, font, etc.).

Limitations and Future Work

First, many of our participants were early-career designers. However, early-career does not mean little design experience. We asked how long our participants had publicly or commercially released content, but we recognise this time does not account for prior experience refining their skills. Mobile content designers further into their career may have a greater awareness of SVIs and use of guidelines or tools that our participants are unaware of. Future work will look to understand how the results in this study compare with designers further into their career. However, it is concerning that designers who have experienced current education and training are mostly unaware of SVIs and the few support resources available. Therefore, it is important that we address this early rather than wait for designers to learn to design for SVIs through trial and error.

Second, only four designers responded to our request for a follow-on interview, yet each participant was at different points in their design careers, had different exposures to accessibility, and varied in the mobile content that they designed, which resulted in diverse information and opinions. All were able to discuss how to address SVIs. The sample size is small, however, the larger sample responding to the questionnaire provides us with the broad overview of designing to reduce SVIs, whereas the interviews were used as a means of discuss certain points more deeply. We will continue to work with a diverse range of mobile content designers to add to the findings of this work. Running a focus group would allow further reflection on these finding and provide an opportunity to outline an approach to creating new guidelines and tools.

CONCLUSION

Many people rely on their mobile devices for both personal and professional use. However, people experience SVIs when using these devices and content design can exacerbate SVIs. We surveyed 43 mobile content designers and ran four follow-on interviews to identify how often SVIs are considered and how we can provide effective support. We found key similarities and differences between accessibility and designing to reduce SVIs. Our participants requested guidelines, education, and digital design tools for improved SVI design support. Consequently, we make recommendations to shape the future of mobile design. (1) Current guidelines need to be extended to include validated SVI guidelines. (2) Information about SVIs must be included within formal education and online popular professional development resources. (3) New design tools, co-developed with designers to fit within their design process, will support rapid designing to reduce SVIs.

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