"It doesn't win you friends": Understanding Accessibility in Collaborative Writing for People with Vision Impairments

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Collaborative writing tools have become ubiquitous in today's world and are used widely in many professional organizations and academic settings. Yet, we know little about how ability-diverse teams, such as those involving people with and without vision impairments, make use of collaborative writing tools. We report on interviews with 20 academics and professionals who are blind or visually impaired and perform collaborative writing with sighted colleagues. Our findings reveal that people with vision impairments perform collaborative writing activities through four interconnected processes, which include learning an ecosystem of (in)accessible tools, adapting to complexities of collaborative features, balancing the cost and benefit of accessibility, and navigating power dynamics within organizations. We discuss how our analysis contributes to theories of accessibility in collaboration and offers practical insights for future collaborative system design.

CCS Concepts: • **Human-centered computing → Empirical studies in collaborative and social computing**; **Empirical studies in accessibility**.

Additional Key Words and Phrases: Blind; vision impairment; accessibility; collaborative writing; ability-diverse teams

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1 INTRODUCTION

Collaboratively creating and editing shared written documents has become a pervasive activity within professional and academic workplaces, with writing practices co-evolving alongside a multitude of tools to support groups of writers working at a distance. Tools such as Microsoft Word, Google Docs, Google Drive, Microsoft OneDrive, Dropbox, Box, LaTeX, Overleaf, and more are ubiquitous across many professional organizations and academic settings. The evolution of these tools has been matched by scholarship that aims to understand how people use new collaboration capabilities, such as synchronous editing, tracking changes or revision histories, commenting, etc. [20, 65, 88, 98], the relationship between user's rationale for collaborative writing and actual editing behaviors [66, 88, 89], and how these tools affect work styles [20, 65, 89] and group dynamics [7, 18, 19, 89]. Despite this extensive body of research, we know little about how ability-diverse

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teams, such as those composed of blind and sighted individuals, engage in collaborative writing using these tools.

Ensuring the accessibility of collaborative writing tools is crucial for enabling people with vision impairments to participate in all aspects of society, from educational opportunities to career prospects to personal growth. This critical need is underscored by the fact that the 7.6 million Americans with a visual disability are less likely to be employed, have lower income levels, and are less likely to pursue higher education [1, 10, 55] than their sighted peers. Given the widespread use of collaborative writing tools in higher education settings and professional work, understanding what makes collaborative writing practices accessible or inaccessible is an essential step towards reducing potential inequities. Limited prior work has examined the accessibility of collaborative writing tools, but the work that does exist suggests that collaborative features on both Google Docs and Microsoft Word pose significant difficulties to screen reader users [26, 75]. Further, people with vision impairments often must cope with and find workarounds for accessibility issues with pervasive technologies. Much of this work has focused on web browsing (e.g., [13, 21, 39, 49, 53, 64, 70, 85]) and search (e.g., [71, 72, 97]), neglecting their practices with ubiquitous word processing software. Widely used word processing software has continued to evolve and now includes features that allow sharing and co-authoring documents using screen readers, keyboard shortcuts, and speech recognition. Although the advancement of these features seems promising, many questions remain around how ability-diverse teams negotiate use of these tools and achieve accessible work practices in collaborative settings.

To help fill this gap in the literature, we report findings from semi-structured interviews with 20 academics and professionals who are blind or visually impaired and engage in collaborative writing with sighted collaborators. Our analysis reveals that collaborative writing for these professionals involves four interconnected processes: (1) learning and maintaining an ecosystem of tools that are largely inaccessible and constantly changing; (2) adapting to complexities of using collaborative awareness features, which subsequently reshape and add to the work of collaborative writing; (3) balancing the cost and burden with the benefits of advocating for accessible group work practices; and (4) navigating power dynamics within organizations that are driven by both ableist and professional hierarchies.

Our paper makes three primary contributions to CSCW. Firstly, our analysis provides an empirical understanding of distributed collaborative work practices among ability-diverse teams. Prior work focuses primarily on co-located interaction among blind and sighted collaborators [23, 24, 31, 57–60, 81, 82, 87, 96, 99], leaving open questions of how these groups decide on which tools to use, coordinate work practices, and achieve awareness when their activity is distributed across time and space. Secondly, we use our findings to build on current theorizing of accessibility and interdependence in collaborative work [11]. In particular, the case of collaborative writing reveals sociomaterial configurations of access, in which a technical breakdown of accessibility often manifests socially; the invisible labor put forth by blind collaborators in creating access, which is culturally and politically positioned as outside of formal work; and how power dynamics and hierarchies contribute to technological, social, and professional disadvantage. Thirdly, we conclude with a discussion of practical design considerations for future collaborative systems and improvements to pervasive collaborative writing tools.

2 RELATED WORK

Our work is informed by research on collaborative writing practices, accessibility in writing tools, web content and ability-diverse group work, as well as literature on disability and access.

2.1 Collaborative Writing Practices

Within CSCW and HCI, researchers have been exploring users' collaborative writing practices using commercially available systems, such as Microsoft Word and Google Docs [12, 20, 65, 66, 88, 89, 98, 101]. Boellstorf et al. [20] detailed how co-authors switched back and forth between asynchronous and synchronous editing and developed new ways of collaboration to increase efficiency. Olson and colleagues [66, 88, 89, 98] studied students' writing behavior in a group and described how they employ various coordinating and writing strategies, for instance, divide-and-conquer, drafting from scratch, starting with an outline, or using a related example as a template for their own writeup.

In addition to activities focused on the writing process itself, Birnholtz and colleagues [18] highlight important group and social dynamics that shape collaborative writing behavior. They showed that users rarely made direct changes to others' work, and if they did, they often left comments explaining those changes – what they refer to as "group maintenance" behaviors. They also found that these behaviors, along with the use of humor or emoticons, were correlated with improved social relationships for those involved in synchronous collaborative writing [19]. Wang et al. [89] found that users sometimes did not want to conduct 'synchronous editing' (at the same time) or 'close co-editing' (at the same place in a document) because they were not comfortable exposing their detailed typing behaviors to others; however, this depends on the task and is less often the case when taking meeting notes, brainstorming ideas, or outlining. Role structure further influenced participants' writing practices. For example, students and employees avoided directly editing their advisors' or managers' writings, but peer-level editing was more accepted.

2.2 Accessibility and Usability of Writing Tools and Web Content

Related to the present paper, prior work has begun to examine accessibility of collaborative writing; however, much of this research focuses on collaboration tools. A usability study with visually impaired individuals found that collaborative features (e.g., revision histories, tracking changes, awareness indicators, etc.) on both Google Docs and Microsoft Word were very difficult to access via a screen reader [26, 75]. Specifically, screen reader users had difficulty understanding the context of the revisions and comments in a document and accepting/rejecting changes [75]. Even accessing basic features in word processors (e.g., creating, formatting and resizing documents, understanding table content, searching text, navigating through different menu options) was challenging for screen reader users at the time of the research [26, 30, 61]. Researchers have introduced several proof-of-concept prototypes to address these limitations [26, 30, 75, 91].

Similar to the challenges with collaborative writing tools, prior work has studied the accessibility and usability of web-based interaction [15, 51, 69, 80, 84], particularly related to dynamic content. For instance, Bigham et al. [15] assert that "not knowing what you don't know" is a major issue with navigating the web non-visually. That is, a screen reader user may not know whether they are experiencing a problem because a particular feature is inaccessible or because the content or information is not present. Indeed, a vast body of work has focused on understanding the ways individuals with vision impairments navigate web interfaces and devise workarounds for accessibility problems in these systems [13, 21, 37, 39, 49, 53, 64, 70, 85]. Given these challenges, researchers have improved the accessibility of web-based content by developing various assistive technologies (e.g., auditory [38, 73], speech-controlled [9, 86], haptic [16, 48] and spatial [44] interactions), personalized and opportunistic adaptations [8, 25, 37, 100], semantic web modeling [8, 9, 16], shared browsing [68], and collaborative [40, 78] and automated [35] evaluation techniques. While this work highlights a number of important challenges with accessing content in dynamic interfaces and suggests technological solutions to address those, there is less focus on the practices

around producing content and social and relational behaviors that are known to be important for collaboration among groups of sighted individuals.

2.3 Accessibility and Ability-Diverse Teams

An emerging literature within CSCW and HCI involves studying the collaborative practices of ability-diverse teams in professional, academic, and personal settings. For example, Zolyomi et al. [102] investigated collaboration within neurodiverse student teams in higher education and detailed the difficulties students face in communicating individual differences and maintaining team cohesion. Wang and Piper [90] analyzed co-located work among Deaf and hearing professionals and put forth the idea that accessibility emerges through multimodal interactions and team practices over time. Closely related to the present study, Branham and Kane [23] investigated how people with vision impairments and their sighted companions negotiate accessibility in shared home spaces, in which relationship maintenance was a key part of creating accessibility. Researchers have also highlighted the 'invisible work' performed by blind employees [24] and the barriers associated with using assistive technologies [87] in predominantly sighted workplaces. Others have studied how people with vision impairments collaborate with sighted persons to form a shared understanding while shopping together [99], performing navigation tasks [96], receiving remote assistance [14, 22, 50], seeking information online [6, 68] and sharing photos [54]. Still other work examines collaborative design among children and educators with and without vision impairments [58, 59] as well as how visually impaired athletes and spectators build an understanding of different social contexts through interaction [81]. As a complement to these studies of collaborative practices, researchers have also developed multimodal applications and co-design sessions to support collaboration among blind and sighted students or colleagues in terms of learning geometrical concepts [60], programming [56, 82], storytelling [31], editing diagrams [57], and composing music [67]. Collectively, this literature highlights the importance of understanding and designing new systems to facilitate collaboration among ability-diverse teams.

2.4 Disability and Interdependence in Collaborative Work

Our analysis of collaborative writing among teams of blind and sighted individuals is shaped by recent theorizing of 'disability' as enacted and situated. Moser argues that "ability and disability are located neither within people nor society, but in the particular sociomaterial arrangement of relations and ordering of practices..." [63]. This framing asks what role technology and material arrangements play in enabling and disabling interactions, and how the notions of disability and ability are produced and reproduced through technology. Our work is also guided by Alison Kafer's political/relational model of disability, in which disability is seen as a product of social relations [42], as well as other feminist disability scholars who reject narratives of disability as dependency and deficit (e.g., [52, 83, 92, 93]). Following from this, scholars from disability studies [29, 95] and recently within HCI [11] have put forth the notion of interdependence as a way of understanding the relational nature of assistive technology use. Bennett et al.'s [11] conceptualization of interdependence attends to collaborative access and the labor people with disabilities do to achieve this. Further, they argue that interdependence—rather than dependence or independence—enables seeing people with disabilities as agents in creating access, which is sustained in relational configurations. Thus, our understanding of collaborative work attends to sociomaterial relations and configurations, the give and take of assistance, who is performing 'invisible' labor, and what power dynamics and hierarchies are at play. Although others have put forth the concept of interdependence for other areas of cooperative work, this has largely been instrumental and focused on task attributes (e.g., [7, 45–47]). Our work takes a broader view

of interdependence that considers task-level coordination details alongside social and structural aspects of collaboration among ability-diverse teams.

3 METHOD

3.1 Participants

We conducted semi-structured interviews with 20 academics, professionals, and accessibility specialists with vision impairments (9 identified as male, 11 as female; ages ranged from approximately 20-50). Participants were recruited through our research network and snowball sampling. All participants except Grace and David are residents of the United States. Participants primarily use screen readers for collaborative writing and technical purposes. JAWS, NVDA and VoiceOver are the most common screen readers they use, while some participants also use Narrator, ChromeVox, and Talkback occasionally. Although some of our participants use Braille Displays, we focused on their collaborative writing practices using audible speech output of screen readers.

All participants use Microsoft Word (desktop version) and/or Google Docs for writing purposes. Several participants use other real time collaborative text editors (e.g., Microsoft Word Online, Overleaf etc.) and cloud storage services (e.g., Google Drive, Dropbox, Box, Microsoft OneDrive, SharePoint, CloudHQ etc.). All participants frequently perform collaborative writing activities with sighted collaborators, except for Kaylee who reported only doing this a few times. Although some of our participants also work with blind and visually impaired collaborators, in this paper we focus on their work with sighted collaborators. See the Appendix (Table 1) for details of participants' self-reported visual ability, occupation, collaborators, and the kinds of documents they produce. For the sake of privacy, we use pseudonyms when referring to our participants. Given the diverse experiences of individuals with vision impairments more broadly, we acknowledge that our participants are unique in that they are all screen reader users (as opposed to those who are low vision and use magnification). Many are educated professionals or academics, experienced with using collaborative writing tools, and work in accessibility-related occupations.

3.2 Procedure

We obtained approval to conduct this research from the Institutional Review Board of our university. Before the start of each interview, we collected verbal consent from the participants. All the interviews were performed remotely via video/audio conferencing tools such as Zoom, Facetime, or Skype as preferred by the participants. The interviews lasted from 40-75 minutes and the participants were compensated with a US$30 Amazon or Visa e-gift card. All the interviews were audio-recorded and transcribed for analysis. We followed a semi-structured format to allow participants to freely talk about their collaboration experiences and preferences. Participants were first asked about the tools and applications they use for collaborative writing and ways they interact with various collaborative features (e.g., comments, replies, track changes, real-time editing features). We asked them to describe their rationale behind choosing different strategies and workarounds, how they discussed collaboration practices with different people (e.g., student peers vs advisors, or colleagues vs supervisors), and how their collaborators view and act on the issues arising in terms of accessibility in group work. In this regard, one important limitation of our study is that we do not directly capture the perspectives of the sighted collaborators, rather we only have our blind participants' account of their collaborators' views with respect to accessibility. We return to this point later in the Discussion.

3.3 Data Analysis

Our approach to data collection and analysis follows constructivist grounded theory method [27, 28]. We began with open coding of our interview data, which included codes that captured, for example, complex and inconsistent shortcuts, comments or revisions being difficult to understand, accessibility regression with software updates, and various workarounds. Throughout our analysis, we wrote analytic memos and engaged in a process of constant comparison of data to data and data to emerging concepts and established theories in the literature. Informed by our earlier interviews, we adjusted our interview questions to better understand emerging themes and probe open areas, such as how collaborators establish new norms and how positions and roles shape the way accessibility is negotiated within different groups. Informed by work from disability studies and feminist scholarship [36, 42, 52, 92, 93], our analysis takes a broader view of accessibility as created through interaction and particular sociomaterial configurations and inherently tied to relations of power.

4 FINDINGS

As we detail below, our analysis reveals four interconnected processes that shape the ways in which blind or visually impaired professionals engage in collaborative writing with sighted colleagues.

4.1 Learning and Maintaining an Ecosystem of (in)Accessible Tools

People with vision impairments regularly learn to use, cope with, and find workarounds for accessibility issues with a wide range of technologies (e.g., [15, 17, 21, 39, 53, 64, 85, 87]). The writers in our study were no exception to this, as they described learning and maintaining a broad set of tools as part of their collaborative writing process. The vast majority of writers switch between multiple screen readers (JAWS, NVDA, VoiceOver, Narrator, Talkback) as they write and edit content in various word processors, such as Microsoft Word, Google Docs, LaTeX documents, and plain text. Although most of these collaborative writing tools provide accessibility support to some extent, participants described having difficulties in accessing certain tools (e.g., Google Docs) due to complexities in configuring screen reader support[1], complicated layout of keystrokes (e.g., combination of multiple keys that are spatially dispersed on the keyboard), and feature-specific settings and shortcuts that are inconsistent with other commonly used screen readers.

> *"It makes reading hard because it [Google Docs] doesn't honor the punctuation settings that you have for your screen reader. And the whole keyboard shortcut mapping of Google Docs is so weird, and it almost never works for me well. Of course it's very intuitive for everyone, lightweight, and I really want to transition to Google Docs full time, but if you look at the accessibility instructions for Google Docs, there is a whole bunch of setup that you need to do before using the tool, and this is not one time. Some of these settings conflict with the other preferences I have for my screen reader. Why do I change this when I just have to go on a web tool and use?"* - Isaac

> *"The way they have designed shortcut keys [in Google Docs], does not match any other screen reader experience that other blind user has. And, some of them are layered shortcut keys that are impossible to use for a long time. For example, you should use this combination- Ctrl-Alt-N and then H to jump to next heading. You can assume, how far [apart] these keys are on the keyboard. This is a silly design. It is accessible but is not usable."* - Alex

Alex echos a common sentiment that accessibility is not the same as usability [15, 51, 69, 80, 84]. Some writers also described certain collaborative features working well in particular combinations,

[1] https://support.google.com/docs/answer/6282736?hl=en&ref_topic=6039805

such as accessing comments in Microsoft Word through the JAWS screen reader, but that the same features did not work equally well across all screen readers or word processors. Writers need to learn which combinations of screen readers and writing tools work well for their particular writing needs and become proficient at using those tools. One participant (Maya) explained that a big challenge is that *"nothing is fully accessible or fully inaccessible. A lot of the technology I use works with the screen reader sometimes. And, sometimes, it doesn't... It becomes really frustrating."* Echoing findings in prior work [17], our informants explained that the keystrokes required for different screen readers and/or collaborative writing tools were inconsistent with each other, and switching between these applications requires memorizing different sets of keystrokes for doing the same work. Nova said, *"I really don't know what all the keystrokes would be to show me all the revisions in a document on a Mac. That's kind of a user limitation as opposed to a software issue..."* She explained that switching to another screen reader *"seems like a big hassle because I have to learn more stuff. I end up sticking with the thing that I know even if it's not perfect."* The boundaries between what is 'accessible' and 'inaccessible' are blurry [15, 36] and largely depend on one's learned ability to navigate this ecosystem of tools and piece together various configurations of software to achieve their goals.

Participants described the "learning curve" of figuring out how to access collaborative tools or features, primarily by referencing online manuals and support documents or by trial and error. Some informants were still unable to get a good grasp on how to use collaborative features (e.g., track changes, comments) through self-teaching. Sofia feels that learning in collaboration with co-workers or IT personnel could be more effective for her, but she is restricted by working in a predominantly sighted environment with co-workers who are not familiar with the assistive devices she uses. She contrasts her ability to work with others to learn new tools to that of her sighted colleagues: *"Sighted people in an office can sit down with a colleague who can literally point and click, and show them exactly how to do each step if they need to... But when you're blind, usually you can't, because nobody in your office uses the same assistive tech you do. They don't know how to do it."*

The work of learning and maintaining this ecosystem of tools is further complicated by regular software updates. Our informants reported that often software updates meant to improve the experience for sighted people had negative ramifications for screen reader users. Sofia said, *"What I don't like about Word is that, something might be working, until suddenly it doesn't. When I get Word documents in email, it puts it in protected view by default and protected view is not screen reader accessible, at least not with JAWS. I have to go into the menus and click 'enable editing', which isn't hard, but it's annoying... That didn't use to be a thing. I think it was a Word 2016 feature."* Maya commented, *"There are technologies, where maybe they were the most accessible [before] and now maybe they're not. I think Microsoft Office apps are good example of that. There was a monthly update [to Office 365] and, all of a sudden, I couldn't read a paper paragraph by paragraph, if there were any track changes or comments."* Similarly, Nova described facing *"barriers depending on what version of Word and what version of screen reader you're using. Right now, my version of Microsoft [Office 365] is crashing every time I try to insert a comment. I'm not really able to collaborate right now."*

Other participants voiced similar concerns, where they often needed to regress to previous versions of software to maintain features they have learned over time and depend upon professionally. For instance, Alex prefers using Microsoft Word 2010 instead of its latest version, since he can easily interact with the comments in a document by pulling up the context menu with a keystroke, *"but unfortunately, with the very very smart and intuitive design in 2016, this context menu does not have any 'edit comment' [option] anymore, which is a shame for Microsoft Word. And so, to the best extent possible, I don't use Microsoft Word 2016. I use Microsoft Word 2010."*

Due to such unpredictable changes in accessibility support, participants described continually needing to stay up to date on the latest software releases and how they might help or hinder their writing and editing work. Mila said, *"There's a learning curve, because I have to learn how the new versions work and what the commands are and what's changed. So it keeps me on my toes!"* Similarly, Nova commented, *"It [VoiceOver for Microsoft Office] may have improved. It's something where you have to keep trying in every three months or so to know whether it works or not. I haven't tried it lately."* Keeping up with technology updates becomes "immense work" for our informants, particularly given other demands on their time:

> *"The most challenging thing ongoing is that technology changes and accessibility changes, and those changes don't necessarily correlate with each other. For me keeping up with what screen reader works with what app is just immense work to the point where I just don't [do it]. There are some technologies where maybe if it was not very accessible when it came out, I haven't really revisited it, because it's so much work for me to, first of all, keep up with the news and know that I should try to use it again. Second of all, trying to use it again in the mix of all the work I have to do."* - Maya

Given the work required to learn to use and maintain this ecosystem of tools, participants described leveraging a combination of tools, devising workarounds, and at times simply "muddling through" the use of collaborative features, which we detail below.

4.2 Adapting to Complexities in Collaboration Awareness

A key aspect of collaborative writing involves maintaining collaboration awareness, or understanding who edited or commented what, where, and when [34]. Breakdowns in collaboration awareness can lead to misunderstandings, duplicate work, dispute over each others' contributions, and even negative social consequences [18, 19]. In collaborative writing tools like Microsoft Word and Google Docs, collaboration awareness information is provided through features like comments, track changes, and real-time editing notifications. Sighted people receive visual cues about collaborators' activities and the document state, such as edits and comments color-coded for different co-authors, inserted text denoted by underlining and deleted text by strikethrough, and real-time edits by co-authors represented through cursor movement and the visible appearance of characters. Screen reader users, in contrast, hear the document text read aloud alongside notifications of edited text, comments, and collaborator interactions (e.g., where a collaborator is editing within a Google Doc). For example, while reading a Word document with track changes and comments, screen readers announce the presence of a comment or revision by saying "has comment", "revision, inserted", "revision, deleted" etc. The JAWS screen reader also reads the comment content and commenter's name or initials after reading the portion of the text where the comment is attached, conveying who made the comment and where it was made. In the case of track changes, JAWS announces who made the changes and when they were made along with the edited text, although this depends on the verbosity setting of the screen reader.

While on the surface it appears that existing tools provide the information required for collaboration awareness, our informants detailed the complexities of understanding and making use of this information during their collaborative writing process. In particular, our informants described the serialized presentation of text-based content and collaborative awareness information as "cognitively overloading," making it difficult to understand the meaning or context of a change and who made the change. This is exacerbated when there are multiple changes within a small portion of the text (e.g., multiple edits to a sentence, or proximal or overlapping comments). Several participants described this complexity:

"I also sometimes find it frustrating that I don't have a good way to keep track of, in collaborative environments where someone has made changes... Track changes tends to muddy the waters very badly. For instance, if I have a document that someone else has changed, I might hear 'the cat deleted rat ate 15 mice changed to'- I'm hearing all of that. Some of it is actual text, some of it is deleted text and [I'm] not having a great difference between the different ones." - Emma

"What might take you 10 seconds to identify, may very well take me three minutes to disambiguate. Because I'm going to read a complex paragraph with changes in complex sentences, from three different authors, maybe even close to one another. So understanding the start and end, the boundaries of changes, and then mapping that to who made those changes is a two part problem. Both are technically 'doable', but definitely not easy to do... You've forgotten the first half of the sentence by the time I get to the middle of the sentence... And across multiple sentences, it's totally ludicrous, right?" - Bill

Given the cognitive work required to understand who did what, where, and when within a document, participants devised alternate strategies for maintaining collaboration awareness. Instead of going through track changes one-by-one to understand edits, participants often listened to the original and new version of each sentence or paragraph without markup one after another. Then, they tried to identify whether there were substantial changes between the two versions. For some situations, however, this workaround was still too cognitively difficult to manage. Emma said it *"ends up very cluttered mentally."* Consequently, some writers accept all changes without reviewing them or ask collaborators to point out important changes in comments, both of which leave the writer with only a partial awareness of their collaborators' actions.

Similar situations arise in Google Docs, where real-time changes by collaborators result in continuous and copious screen reader announcements, which our informants find extremely difficult to follow. When writing with others in Google Docs, participants explained it as difficult to focus on their own writing when the screen reader keeps announcing which collaborators are entering or leaving the document, the specific paragraphs they are editing, and what they are typing. Several writers explained that real-time collaboration often turns into asynchronous interaction, where they wait for others to finish typing and then go back to listen to what they wrote:

"The feedback that I receive what she [collaborator] is typing, it's not intuitively understandable. Visually you can follow... But, that would be cognitively overloading for me. Because meanwhile that she is typing, screen reader is just uttering nonsense to my ears for each character that she is deleting or she is inserting. And later on, I have to ask her to pause, because I didn't have a good amount of time to read while she was doing it. It becomes like a kind of asynchronous thing." - Alex

" It [screen reader] doesn't verbally announce the changes as they happen, as far as I know. And even if it did, that would be confusing, because if I hear random words and letters that they're [collaborators] typing, that wouldn't make sense. So, I wait until they're done so that I can more easily navigate changes." - Lily

To address these issues, our informants implement different workarounds while using track changes in Word or collaborating real time in Google Docs. For example, Bella, Emma and Daniel turn off screen reader announcements related to changes made by others in the document, effectively ignoring collaboration awareness cues. Other informants adjust their writing strategies so that they can contribute in a document without paying attention to what others are doing. For example, they often coordinate work through a divide-and-conquer [89] strategy, where group members can independently write different sections in the same document or in completely separate documents. The divide-and-conquer strategy provides flexibility in choosing an application that works best for

each person without making others switch tools. For example, on one project, Ryan converted a Google Doc file shared by his collaborators into a Word file and emailed the Word file back to them.

> *"That was something where it definitely needs to be collaborative... [we] each have to write our own section. And that's kind of circumstances, where people suggested, 'Let's do this in a Google Doc.' And I said, 'Well, you guys can do it in a Google Doc if you want, but I am going to download the document. I'm going to edit my part the way I want it and then I will send you my part. You can put it back in.'... So, that's really like me working around the problem."* - Ryan

The divide-and-conquer strategy also reduces the risk of accidentally changing others' work, specifically when users do not have clear understanding of what their collaborators are doing at that moment in a document. Indeed, participants expressed concerns that they will "mess up" another person's work due to lack of collaboration awareness. Elena explained, *"It's hard to be in any flow with that [Google Docs collaboration announcements], but yet you're so worried about editing right on top of someone else."* Similarly, Maya said, *"Sometimes, in Google Docs, I can tell that I screwed something up. I just have to email the collaborators and say, 'I think table X needs to be fixed' or something."* These breakdowns in collaboration awareness mean that writers need to communicate and coordinate through other means, particularly when collaborators are expecting them to have a certain level of awareness and thus behave in a particular way. While groups of sighted collaborators may not want to do 'close co-editing' in real-time because this exposed too much detail about their actions [89], our informants avoided this practice because they did not have enough information to avoid coordination difficulties.

Commenting features within collaborative writing tools are an important mechanism for achieving collaboration awareness [94, 101]. Our informants described establishing new norms around how commenting features were used due to the complexities of accessing, resolving, and replying to comments through screen readers. Participants described various workarounds for accessing comments, one of which involves pulling up the list of comments and then navigating through this list and back and forth to the text in the main document where the comments are anchored. That is, they must infer which comment applies to which parts of the text to distinguish between replies and comments or overlapping comments. Alex described his technique to understand replies as a *"daunting task of using JAWS to separately capture the comments,"* which involves switching back and forth between the NVDA and JAWS screen readers, navigating through the comments in the main document, and matching with a plain text file that contains the list of saved comments. To bypass this tedious process, Alex asks that his collaborators not reply to comments but instead insert their replies as separate comments next to the parent comment and add contextual markers such as *"in reply to this."* Similarly, Maya explained that she makes collaborators aware that she cannot resolve or respond to comments and that she may miss comments if they are on top of each other or too close together. She tells collaborators, *"If you notice that I don't address some of your comments and if you [are] passing the paper back and forth, please bring it up in an email because I may have missed it."*

Given the complexities of existing comment features, many other informants described using inline comments within the document instead. Daniel explained, *"We'll just write these comments right into the document rather than using a feature. We'll just use initials, kind of like Word does. I might say 'DH: change this'... If everybody on the team is technical enough, I might say, put a semicolon and then put some kind of comment in there, or do the star slash or something."* Some writers, as Daniel described, worked out new commenting conventions that aligned with the interaction style of a screen reader, where comments are read inline with text, rather than interspersed back and forth with markup, and denoted by a special character. The special character makes the inline comments noticeable for screen reader users and searchable within the text.

While our informants frequently adjust work strategies, some described these strategies as *"reducing overall collaboration," "outside the realm of collaboration,"* and *"not as much collaboration because its one way."* One reason for this perception is that using a divide-and-conquer strategy, for example, distributes work individually across separate documents. Similarly, asynchronous editing in Google Docs defeats the purpose of having real-time editing capabilities. Informants described these adaptations, as well as other workarounds (e.g., inline comments, email feedback using contextual markers), as *"not true collaboration"* and more *"transactional"* rather than collaborative. Some even called these adaptations *"old school,"* or *"old-fashioned"*, suggesting they are not indicative of contemporary collaborative writing practices. Thus, what is viewed as 'successful' and 'real' collaboration is defined by normative practices of sighted colleagues and the ability to use state-of-the-art collaborative writing tools.

4.3 Balancing the Cost and Benefit of Accessibility

Analyzing collaborative writing reveals multiple forms of labor that blind or visually impaired individuals must perform, such as learning and maintaining an ecosystem of technologies and reformulating collaborative awareness practices during group work. The case of collaborative writing also reveals the work these individuals perform when they ask their collaborators to change their tool usage and routines to achieve more accessible group work practices. This is particularly difficult when an individual feels that sighted collaborators do not understand how blind people interact with technology or view accessibility as extra work.

> *"They [sighted people] were never exposed to accessibility in a way that negatively potentially could impact their workflow or their employment prospects. I think they only understand accessibility on a surface level, where they might encounter it... I think they just assume by default that everything's accessible, so when they say, 'Oh, let's use Google Docs,' and they don't really hear any objections or anything like that, then they think that it's okay to use it."* - David

> *"If we change it to a different way of doing things, I think sighted people just think it's extra work... When they're asked to do something that they see as being less effective for them, they don't like it. They don't want to do that... It just becomes a burden for everybody, and nobody really cares or wants to do it."* - Daniel

> *"Accessibility doesn't have a very good reputation. It's seen as a drag. It means extra work, extra time, extra money."* - Sofia

Within the context of collaborative writing, deciding when to advocate for more accessible practices depends on whether and to what extent the individual can contribute to the project. Several participants expressed that they actively advocate for more accessible practices in situations where they are unable to participate at all. Ryan explained that he would argue strongly for accessibility if he *"couldn't write, or I couldn't contribute"* but that he also tries to *"weigh how much of an inconvenience or problem is this for me against is there a legitimate reason on the other side where they don't want to do this?"* Addison said, *"If it's really difficult for me, I'll fight for change. If it's not and I can adjust, I just go with it."*

Determining how "legitimate" the concerns of the individual and their collaborators are also depends on situational factors and project specific constraints. For example, increased time pressure and word limits influenced how our informants advocate for their accessibility needs in different contexts. Ryan, David and Sofia described cases where they agreed with their collaborators to use Google Docs due to time pressure and deadlines, even though the software was not fully accessible to them. David explained that *"it's kind of hard to push those [deadlines] back because of accessibility issues."* As another example, Ryan did not advocate for accessibility in his internship position, since

he was working there for a short span of time: *"It was just that I couldn't use it, and, again, that's more okay to live with when I was only going to be there for a couple of months, but I don't know how to deal with things like that, when I look to the future and getting into a more long-term employment situation."* Similarly, for a one-time project at a workshop, Sofia agreed to convey her ideas verbally while her collaborators worked on Google Docs. She pointed out that if the project was important for her employment, *"I would have been having a different conversation."*

The decision to ask group members to change to more accessible practices, however, is rarely straightforward. Our informants consider the cost of the group's current practices on their own ability to contribute, efficiency, and availability of information against the "extra work" that shifting towards more accessible practices would impose on their collaborators. Several informants noted that co-located editing and reading changes aloud was a useful strategy for them, but acknowledged that this takes time and can be difficult for busy collaborators. For instance, one of Lily's professors gave feedback on hard copies. In some cases, she would go to them and they would read out their comments to her. However, she said she would only ask the professor to do this when the information was essential, such as comments on an important paper. She explained, *"Sometimes I just wouldn't ask, because I didn't want to take their time... But if it was a big paper, and because I needed to know what they said, I just would have to go and ask, even if it was hard for me to do."* In this case, the student faced a decision of either not knowing what the comments were or imposing on the professor's time. As another example, although many informants said that inline comments were accessible and preferred, Isaac, Maya, and Bella said that their use of inline commenting was likely more difficult for sighted people. Inline comments remove visual cues for their sighted collaborators and *"kind of made it a lot more difficult for her [collaborator] visually...it definitely provided fewer visual sign posts for her to understand what was going on."* Reasoning about the effects on one's collaborators was a key part of the decision making process, although future work should examine the perceptions of sighted collaborators and how their views align or misalign with the perceptions of blind writers.

As the previous excerpts begin to illustrate, making decisions about how to balance the cost and benefit of accessibility cannot be separated from the social context in which these decisions are made. Our informants reflected on the social 'costs' of asking collaborators to change their practices:

> *"There is a feeling always with me that, of course, this is not my fault. This is technology's fault. But when you want to ask collaborators, 'Would you please downgrade yourself to something else that I'm using,' or 'if you're using Microsoft Word 2016 or 365, would you please use the compatibility mode so that it complies with my Word 2010?' You know, socially it's little bit [of a] bummer, mentally and emotionally."* - Alex

> *"In the middle of the project when the accessibility of that technology which I told them [collaborators] I need to use, changes, and I have to think, 'Oh crap, already I'm making these people go out of their way to use the technology they don't want to use, and now we may have to switch to something else, or I may have to ask them to do something differently.' That's really hard socially and professionally. That's a huge, huge challenge that is just really frustrating to me."* - Maya

Social norms governing what it means to be a 'good' group member further shape the decision of whether and how to ask for alternate work practices. As such, our informants understood that advocating for more accessible collaborative writing practices could have negative social and professional ramifications. Daniel said, *"Anytime you need to ask for an accommodation or insist that things be done in a different, more accessible way, you'll take a big risk... of being seen as not a team player or risk of being viewed as not an effective employee... That's why a lot of times blind people*

just muddle through with a solution that maybe doesn't really work well for them." Daniel further explained that advocating for more accessible practices in his workplace involved several days of *"drama, back and forth emails with people about why we have to do that."* He said, *"Unfortunately, we ultimately had to get a supervisor involved...But that's not a great way to work with your coworkers... Whenever you try to insist on a thing, it doesn't win you friends and it doesn't influence people very well."* Daniel mentioned that this situation was even documented in his performance review.

Others described similar tensions around accessibility and not being a good team member. Reflecting on his decision to go against his collaborator's practices and work in a more accessible way, Ryan said, *"I think maybe I'm not a great partner, because honestly it wasn't really like a collaborative decision-making process."* Grace commented, *"Sometimes I ignore, because I'm fed up fighting to get the accessible version. So I say, 'Okay, do your work alone...'"* On a similar note, Sofia explained, *"It feels like every time I advocate for myself, I have to do a cost benefit analysis, and sometimes being right kind of sucks, because it loses you a lot of, not just friends, but colleagues or good will."* She described one experience in which she advocated for accessibility that resulted in *"so much collateral damage that it was heartbreaking,"* reinforcing that asking others to change practices has significant relational costs.

As the above excerpts highlight, balancing the cost versus benefit of accessibility and advocating for accommodations is both a form of work and social liability for our informants. One informant (Sofia) summarized this sentiment well by saying, *"It's actually an intuitive skill that I've learned from just years of living in my own skin.. It's a whole series of calculated assessments of whether I want to be right or I want to be effective... It depends on my risk analysis and cost versus benefit, what can I gain, but what can I lose in the process? It really just depends on which I find more important that day in that situation."* Hence, there is no clear cut 'solution' to accessibility but rather a series of tradeoffs related to the work of creating access and who bears the cost.

4.4 Navigating Structural Disadvantage and Power Dynamics within Organizations

Beyond the social costs and additional labor of advocating for accessible collaborative writing practices, our informants must also navigate structural disadvantage and power dynamics associated with ableism and within professional workplaces or higher education [33, 43]. The work required to learn and maintain evolving collaborative writing tools can have significant consequences for professionals. In particular, our informants explained that they have to work harder than their sighted collaborators and even then may not be able to perform to their fullest potential. Daniel explained, *"Unfortunately, it just makes the process for the blind person who's participating sometimes less efficient... maybe the quality of their contribution isn't as good as it could be as a result."* David also said, *"I ended up having to work a little bit harder than everybody else... At the same time that we were doing work, I basically had to teach myself how to use Google Docs with a screen reader, and also figure out workarounds for some of the accessibility issues."* Other participants, such as Isaac, also echoed this sentiment, *' 'It's frustrating... why can't I be just as efficient?"*

Beyond inefficiencies, participants recalled situations where they felt they were unable to apply for certain jobs because of a team's set practices (e.g., commenting on PDF files) or faced delayed promotions due to the inaccessibility of collaborative tools:

> *"I researched this for about three months and I could not find any way that you were able to comment on the PDF...or to see others' comments there. And so because of that, I was not able to take that job. It wasn't for lack of research on my part, that's for sure."* - Addison

> *"I pretty much got left behind. I had a position where I was helping out other associates and I lost that position, because I couldn't collaborate with them using Skype... So opportunities were*

becoming available for people- all my other friends that were leads. But I lost this opportunity, cause I couldn't use the tools..." - Ethan

Understanding the labor required to learn and maintain the ecosystem of (in)accessible collaborative writing tools alongside the demands of professional work reveals significant issues around inclusion and inequality, as others have found as well [17, 33, 43]. Participants characterized technology as putting them at a disadvantage and leaving them unable to "actually collaborate," which has significant professional consequences.

"It's not how most other people collaborate. I feel like I'm not on an equal playing field, because I'm not able to actually collaborate... This problem is really difficult for people who are in professional careers who need to be able to collaborate on documents... I want to be equal." - Nova

"We need to be able to walk up to a project and use what everybody's using and not have to ask for something different... Anything else puts us at a disadvantage and often just doesn't work well... It's hard enough for me as a blind person to get a job in the first place." - Daniel

"I've always held myself to the same expectations as other sighted people, in that I should use the same tools that they do and be able to do things as efficiently as them... I have to always come up with a workaround just to compete... It's really hard to be employed as a blind person." - David

Our data reveal the combined effects of ableist and professional hierarchies, to which informants must negotiate whether, how, and which adjustments in collaborative writing practices they request. Advocating for accessibility depends on an individual's role within their organization and associated power dynamics, as Emma explained:

"If it's a mix of blind and sighted [collaborators], it often depends on what sighted people are most comfortable with, or what the person who is the highest on the totem pole, whether they be blind or sighted, is most comfortable with. So, if I'm collaborating with the president of an organization, I do whatever the president finds easiest, because they're the one with the most power in the space."

When our informants were themselves in positions of power, they were more able to set the terms of the collaboration. Maya commented, '*I tried to become more transparent with my colleagues and not be afraid to stand up for myself and feel like if I'm the leader on a project, we are going to use the technology that's accessible for me."* Daniel also explained, *"If I'm obviously the boss, I can sort of make the decision [about how things are set up. And I can choose a system that's more accessible, product that's more accessible or a way of doing things that's more accessible. And I can have that expectation that the rest of the team is going to need to fall in line with the decisions that had been made."* He concludes, however, that blind persons are rarely in authoritative positions and most often have to accept working in the way decided upon by their sighted collaborators.

The most common dynamic participants expressed was needing to advocate for accessible practices to people in positions of power (e.g., boss, faculty advisors). Ethan said, *"Until you convince one of the relationship managers that they need to change it, things won't change."* Similarly, Nathan explained a situation where his dissertation committee members wanted to give feedback on his dissertation using tools he did not find accessible. Instead of convincing multiple faculty members to all use the same tools and features, he resorted to getting feedback on hard copies with assistance from human readers. However, this process was time consuming and difficult given that the human readers did not understand technical jargon. Ryan described a similar situation where his professor left comments on a hard copy. He preferred to have feedback through track changes in a Word document, but his professor did not know how to use track changes. Ryan explained, *"This guy, he's 70 something years old, he's a very accomplished man in his field. I'm not trying to make him feel*

like an idiot. He doesn't know how to use track changes." In this example, Ryan worked out a more accessible alternative (i.e., inline comments) than receiving comments on paper but was well aware of both the power dynamic and potential to make his professor feel "*like an idiot.*"

Power in negotiating accessibility also comes into play with respect to employment status and relation to collaborators. Individuals decide whether and how to ask for changes in collaborative writing practices depending on the security of their position and who they are asking:

> *"There's a level of privilege that comes from feeling secure in your job. If I was new to the company, or if I had a brand new manager, or if I knew, for example, we were going to be doing layoffs soon...I would be different. I would not be half as assertive about people changing for me. I would do my best to minimize the inconvenience to other people, because I would want to be proving my relevance to make sure I can keep my job."* - Sofia

> *"With my student peers, it's much easier to be a little more forceful and just tell people how it's going to be rather than making requests, ... whereas in an employment context, you can't do that so much of course, right?... If it was my boss, I wouldn't just be like 'Here's what I'm going to do.' Now you have to be like, 'Here, could we try it this way or would this be okay for you?' It's a different conversation... So, that's just kind of power dynamic, right? That's all that really is."* - Ryan

Familiarity and comfort with collaborators also shapes the way our informants negotiate accessibility. Maya described using inline comments only when she is *"really comfortable"* with her collaborators. However, she still feels "guilt" in asking her advisor to switch to alternative techniques when accessibility breakdowns occur in the middle of the project *"even though she's one of the most supportive people. I don't know what I would've done if she wasn't supportive or if I hadn't had years of experience working with her."* Similarly, Lily prefers to ask for help from the instructors at her prior institute as opposed to her classmates at her new institute, since she feels more comfortable in asking for help from someone who knows her personally. Thus, comfort and familiarity with collaborators may help neutralize these power dynamics to some extent.

Other participants seek to normalize accessible practices by announcing a request for people to speak up about accessibility concerns in team meetings or using humor. The use of humor may help challenge accepted norms within a workplace and call out inadvertent forms of discrimination.

> *"So often I heard presentations and they would say, 'I have handouts, but I'm sorry I didn't have time to get this together in Braille.' And so, when I did my presentation, I brought a big stack of Braille to the front and I said, 'I'm so sorry, I have handouts together, but I didn't have the time to get them together in print.' And they laughed because they heard it all before, but I hope I made a point."* - Addison

Although accessibility compliance in U.S. workplaces and educational institutions is legally mandated, policies are often not enforced and depend on the individual to self-advocate for accommodations [33, 43]. Few participants mentioned using legal justification or argumentation when asking collaborators to change to accessible practices. Ethan said, '*It became an issue to where it got escalated to our bank's ADA Department. And at that point, that's when they finally reached out to Microsoft and said we need to fix."* Conversely, and echoing findings in prior work [11, 32], Addison feels that humanizing the process of negotiating access is more effective than referring to strict guidelines to make collaborators realize the importance of accessible practices. She commented, *"I think when they [collaborators] think of accessibility as involving people instead of involving hoops that have to be jumped through, it was a little easier to swallow. And they seem to get it and become*

over time a bit more tolerant." Even with legal justification and other forms of explanations, negotiating accessible collaborative writing practices is far more nuanced and subject to multiple power dynamics, social pressures, and stigma [76, 77].

Beyond navigating power dynamics at an interpersonal level, our informants described power dynamics within organizations and institutional barriers that shaped collaborative writing practices. For example, in large-scale bureaucratic workplaces, even if collaborators are willing to switch to alternative accessible tools, this may be difficult due to systemic constraints such as security protocols and company set practices.

> *"Last summer, I was at a large law firm, which is where I'm from and they were definitely willing to work with me too. But I could just see that when there are more constraints from a corporate bureaucracy and the kind of IT that they use and the way that they do things, definitely there was a need to explain accessibility needs, but also there were competing concerns that sometimes meant that all the accessibility needs couldn't be met... I guess that is to say that even when people are receptive to it and care about it, still countervailing concerns sometimes make it the case that those accessibility needs just can't be accommodated or won't be accommodated."* - Ryan

Even those informants who worked at organizations focused on accessibility or disability issues described needing to navigate organizational barriers and receive help from others (e.g., support from IT). While these participants explained that their co-workers were sensitive and thoughtful about accessibility given their field of work, achieving accessible collaborative writing practices still required considerable negotiation and additional labor on behalf of all team members.

5 DISCUSSION

The present analysis of collaborative writing leads us to reassess the notion of accessibility in group work and provides insights into improving interaction with ubiquitous collaborative writing tools.

5.1 Rethinking Accessibility in Group Collaboration

Rather than viewing technology as either purely accessible or inaccessible, our analysis and work by others (e.g., [36]) highlights how technology may be 'accessible' for particular people at particular times and under certain circumstances. Our analysis further demonstrates that accessibility of a technology is distinct from its usability by people with disabilities [15, 51, 69, 80, 84]. To extend current theorizing of accessibility in group work, we revisit our findings with respect to the concept of interdependence. Within CSCW, the notion of interdependence has largely focused on properties of a task and the extent to which group members need to coordinate and collaborate to achieve task goals [7, 45–47]. Accessibility scholarship and disability studies emphasizes other aspects of interdependence, including broader sociomaterial relations, the labor of people with and without disabilities, and power dynamics and hierarchies [11, 95]. Here, we revisit our findings with respect to this broader conceptualization of interdependence to enrich our empirical and theoretical understanding of how accessibility is created through group interaction.

First, the concept of interdependence calls attention to relations with other people and one's material environment (see also [23, 42, 62, 63, 90]). We find that our informants create accessibility by negotiating practices and workflows with collaborators as well as learning and navigating an ecosystem of technologies, including screen readers, word processing tools, and associated collaboration features (e.g., track changes, comments). That is, accessibility in collaborative writing is produced through their active negotiation of these sociomaterial relations. When collaborative features do not work as expected or are difficult to use, our informants shifted their own working strategies and developed new practices with others. In doing so, many engage in conversation with their collaborators, advocate for their accessibility needs, and develop new shared norms

for group work. At times, however, asking collaborators to change their practices to support a more accessible workflow can make these individuals feel like a 'bad' collaborator and that the resulting solutions are *"reducing overall collaboration."* While a more deterministic perspective would single out technology as the sole culprit, our analysis provides further empirical evidence of accessibility as an interactive relational process in which sociomaterial contingencies manifest through not just inefficiencies but also resentment among collaborators and disruption of working relationships. Thus, our analysis demonstrates that interdependence must also attend to the social 'cost' of accessibility and the ways in which this cost shapes whether and how people ask for more accessible practices in professional settings.

Second, interdependence centers the labor people with disabilities put forth in creating access. Our analysis of collaborative writing enriches how we understand this labor in the context of ability-diverse group collaboration. Keeping up with the state of collaborative writing tools, educating sighted colleagues on accessibility, and proposing alternative strategies to teammates are just a few examples of the "immense work" that blind and visually impaired writers do as part of collaboration. While some of this labor is tangible, other complex cognitive and relational work may remain 'invisible' to sighted collaborators [24, 79]. Part of this invisible work involves the emotional labor and social stress of analyzing the cost versus benefit of advocating for accessible practices, in which an individual weighs the importance of accessibility in that situation to the potential burden it may impose on collaborators as well as potential social ramifications. In many cases, sighted collaborators adjusted their practices to be more accessible (e.g., using inline comments, reading comments aloud, editing face-to-face), though participants still expressed feeling bad and having "guilt" from asking people to change their ways of working and introducing new inefficiencies for their collaborators. That is, many participant discussions of accessibility implicated a zero sum game in which an individual's gain or loss in accessibility was balanced by the losses or gains of collaborators (e.g., in efficiency, familiarity). Improvements to technology, as we describe below, could certainly change this dynamic and have the potential to shift the labor of creating accessibility and who bears its cost. Nevertheless, our analysis suggests that when accessibility is culturally and politically positioned outside the realm of 'routine' or 'formal' work for able-bodied people [74, 79], this labor put forth by people with disabilities is likely to remain either invisible to or a "burden" or "extra work" for able-bodied collaborators.

Third, interdependence highlights how access is shaped by power dynamics and hierarchies. Those who reported being more assertive in advocating for access indicated that their employment status was more secure and that their competency was already valued by sighted colleagues. Although a few of our informants were in positions of power (e.g., supervisor, project lead) and had greater ability to establish accessible group work practices, others acknowledged that people with disabilities are rarely in such positions of power. Further, individuals feel that speaking up about accessibility could be "risky" for one's employment or would be dismissed altogether due to established organizational workflows. In contrast to interpersonal relations of power, organizational ableism is more challenging and enduring [33, 43]. In large corporate organizations, rigid bureaucratic practices can present barriers to access that may be impenetrable despite ongoing advocacy and earnest effort from both people with vision impairments and their sighted collaborators.

In addition to revealing these power dynamics, our analysis provides further evidence of how difference between ability and disability is produced and reproduced through technology [36, 62, 63]. That is, new collaborative tools impose new expectations for competency: "[D]igital media create new interfaces, actions and expectations for human bodies and may create disability...through the social pressures that increasingly construct the functional life to be the technologically competent life, rendering those who do not master these technologies effectively disabled..." [36]. When accessibility in collaborative tools is an afterthought or requires post-hoc adaptation, this reifies

a subordinate social position of people with disabilities and an ableist hierarchy among professional teams. These asymmetries become even more problematic when professional success and advancement depends on proficient use of the same tools that contribute to this disabling and when productivity is measured against that of able-bodied people [33, 43]. Our participants echoed this sentiment through their desire to be as efficient and proficient as sighted individuals during collaboration, reporting that they work harder than their sighted collaborators to produce the same amount of output. Collaborative writing tools, albeit *"supposedly accessible"* as an informant said, are neither easy to use nor robust in a diversity of real life situations [15, 51, 80]. Instead, these technologies ultimately reproduce the same asymmetries and power differentials they aim to mitigate [62, 63]. Thus, our analysis reveals how disadvantage can be technological, social, and structural, which broadens the scope of what an interdependence frame can bring to understanding hierarchical organization and power in collaborative work.

5.2 Rethinking the Design of Collaborative Writing Tools

As our analysis reveals, a central challenge to accessibility in collaborative writing engagements emerges through strained relations co-occurring among people and their material environment. A breakdown in technology (e.g., a certain feature is incompatible with a particular screen reader) can also become a breakdown socially. We hope one outcome of the present study is a heightened awareness of the wide-spread incompatibility of various screen readers, word processing tools, and collaboration features. Addressing these breakdowns in compatibility across this ecosystem of tools is a first step; however, what makes something 'compatible' is socially evolving and created through configurations of unique teams and work practices. Rather than viewing design for accessibility as a series of features that must work together, we can conceive of access as a "way to move" in the world [32, 33, 36], raising our collective standards of what accessibility in group collaboration should be. With that in mind, we discuss ways to improve the design of collaborative writing tools that align with this conceptualization of accessibility in group work.

One reason the labor of creating accessibility in collaborative writing largely falls on people with vision impairments is because accessibility is often a post-hoc adaptation to tools created for sighted people. More specifically, the serial nature of audio through screen readers is a key challenge that underlies existing system design and use of collaboration features. Sighted people are able to process text in a document alongside visual markup, taking advantage of spatial representations (e.g., nested comments), overlays, and color coding. However, as our analysis shows, the design of collaborative features (e.g., comments and changes) for screen reader users pales in comparison to that for sighted people. Consequently, the process of writing and editing becomes cognitively demanding for visually impaired writers and requires them to find alternative workarounds bypassing traditional interfaces. In this regard, design changes can potentially redistribute or reshape some of the work individuals with vision impairments and their sighted collaborators have to do to make collaboration information accessible. For instance, manipulating the screen reader voice to represent actions of various collaborators could help identify who did what. Similarly, using spatial audio, varying other qualities of audio (e.g., pitch, timbre), or using earcons [2, 41] could enrich the experience and help people disambiguate between document content and collaboration markup. Participants also expressed wanting different levels of information at different times. Though verbosity settings help with this to some extent, introducing summarization of key edits or comments (either automatically [3–5] or denoted by collaborators) could be useful. However, user reactions to different representations are likely to be highly subjective and contextual.

Another hurdle towards establishing accessible work practices comes from underlying power dynamics and role structures in ability-diverse groups, and the burden of raising awareness of these issues is largely shouldered by visually impaired collaborators. Although power dynamics

rooted in ableist and professional hierarchies are difficult to shift, designing collaborative tools that push awareness information on able-bodied collaborators may be a productive way forward. Technology design could help foster greater societal awareness of accessibility and the labor involved in creating access in several ways. For example, the information conveyed through existing mainstream collaboration awareness features flows primarily in one direction; blind or visually impaired individuals may miss comments or edits without collaborators knowing why or what happened. Instead, systems that allow screen reader users to automatically push notifications of certain actions (e.g., reading or missing a comment) to their able-bodied collaborators could help others identify gaps in awareness across the team and take initiative to resolve them. As another example from our data, collaborators upgrade software with the hopes of improving work practices only to learn that these changes negatively affect accessibility. Revealing potential screen reader compatibility issues within software platforms could raise awareness to able-bodied collaborators and organizations who make decisions about company-wide policies (e.g., IT departments).

5.3 Limitations and Future Work

An important limitation of our study stems from the fact that we primarily rely upon self-report data drawn exclusively from professionals and academics with vision impairments. During the interviews, we asked participants to reflect on their collaborators' attitudes towards accessibility and then reported these findings as they described. However, we did not capture their sighted collaborators' perspectives directly. To address this, future work should focus on interviewing sighted individuals to understand their experiences in working with blind collaborators and adopting to accessible work practices. Additionally, future work could involve firsthand observation of people with vision impairments performing collaborative writing in order to better understand their moment-to-moment interaction with the tools and their collaborators. Another important aspect to consider is that most of our participants are experienced in using collaborative tools with screen readers and collaborating with sighted colleagues. To better understand the "learning curve" of accessibility in collaboration, future work could explore how novice users of assistive technology or beginners in group work learn to use collaborative tools and coordinate with their collaborators. Finally, future work could investigate work practices of visually impaired individuals holding authoritative positions to develop a more holistic understanding of how power and role structures shape discussions around accessibility within ability-diverse groups.

6 CONCLUSION

Through our investigation of the collaborative writing practices of professionals with vision impairments, we uncover the complex ways in which accessibility is created and negotiated by ability-diverse groups. Like many other mainstream technologies, collaborative writing tools and features are often designed with sighted people in mind. Thus, performing collaborative writing using these technologies brings about unique situational demands on people with vision impairments. To achieve accessibility, blind individuals and their sighted colleagues adjust their working styles and establish shared norms and strategies within the group. These strategies are developed through complex interactions and negotiations between blind and sighted collaborators and are contingent upon their interpersonal relations, power dynamics, and sociomaterial contexts. Highlighting these nuances of accessibility in group work, our analysis raises new opportunities for further empirical research and design of inclusive systems to better support collaboration in groups with diverse visual abilities.

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A DETAILS OF INTERVIEW PARTICIPANTS

Table 1. **Participant information (all names are pseudonyms)**

Name	Self-reported Visual Ability	Occupation	Collaborators	Documents Produced
Addison	Totally blind since birth	Customer service assistant, assistive tech instructor, blogger	Book editor, colleagues, accessibility trainee students	Assistive tech manuals, tutorials, books
Alex	Legally blind from Retinitis Pigmentosa, gradual vision loss vision	PhD student, accessibility researcher	Advisors, student peers	Research papers
Bella	Nearly totally blind since birth, some light perception in one eye	Assistive tech trainer, blogger	Accessibility trainee students, family members	Website content, presentations, papers
Bill	Profound vision impairment, some light perception in one eye, gradual vision loss	Entrepreneur, accessibility consultant	Museum and industry professionals, academics	Research papers, website content, blog posts, books
Daniel	Totally blind since birth due to glaucoma	Accessibility consultant, blogger, (past: customer tech support)	Colleagues, family members	Technical articles, assistive tech related articles
David	Nearly totally blind since birth, some light perception	Contract employee (quality assurance, usability testing)	Colleagues, (past: student peers)	Assistive tech articles, (past: course projects)
Elena	Nearly totally blind since birth, some light perception	Accessibility and assistive tech specialist	Colleagues, executive directors	Assistive tech related grant proposals
Emma	Legally blind, nearly functional print vision in one eye, born with cataract, developed glaucoma	Accessibility and assistive tech specialist	Colleagues, lawyers, directors	Assistive tech related articles
Ethan	Totally blind since 12 years old	Business trading analyst, blogger	Colleagues, managers, family members	Business report, technical guides, Website content
Grace	Totally blind since 19 years old	Digital accessibility consultant	Colleagues, parents and secretaries in child's school	Meeting notes, project proposals, assistive tech related articles
Henry	Nearly totally blind since 9 years old, some light perception	Accessibility consultant, blogger, entrepreneur	Colleagues	Event planning documents

Table 1. **Participant information (all names are pseudonyms)**

Name	Self-reported Visual Ability	Occupation	Collaborators	Documents Produced
Isaac	Nearly totally blind since birth, light perception in one eye	PhD student, accessibility researcher, (past: research intern)	Advisors, student peers, (past: colleagues at internship)	Research papers, course projects, reports
Kaylee	Totally blind since birth	Applied Sciences Degree student	Professors, friends	Exam papers, shopping list
Lily	Nearly totally blind since birth due to Retinopathy of prematurity, light perception in one eye	BS student	Professors, student peers	Course projects
Maya	Totally blind for 12 years	PhD student, accessibility researcher, activist	Advisors, student peers, undergraduates	Research papers, class projects, social events
Mila	Totally blind since birth due to retinopathy of prematurity	Museum consultant, researcher	Colleagues, students	Research papers, books
Nathan	Legally blind from Retinitis Pigmentosa, gradual vision loss	Research assistant	Advisors, student peers	Research papers, dissertation, course projects
Nova	Nearly totally blind, some light perception, born with retinopathy of prematurity and glaucoma, gradual vision loss	Attorney, accessibility advocate, assistive tech analyst	Colleagues, supervisors, executive directors	Legal documents
Ryan	Nearly totally blind since birth, some light perception	Grad student, (past: intern at law firm)	Professors, student peers, (past: colleagues and supervisors at internship)	Course projects, court orders
Sofia	Legally blind due to congenital glaucoma, some light perception, gradual vision loss	Customer tech Support (work from home)	Supervisor, colleagues, parents and teachers in child's school	Help center documentation, assistive tech user guides

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