Exploring Opportunities in Disabled Technology Adoption with a Lens of Game Design

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Abstract

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The process of adopting technology is complicated, with many variables affecting how and why people might adopt or reject a particular tool. This process becomes further complicated when consider accessibility, disability identity, and the unique roles technology is expected to play in the lives of disabled individuals.

Building on a three-stage model of Discovery, Evaluation, and Adaptation in technology adoption, I explore the unique considerations of a disabled approach to this process, informed by disabled lived experience and a recognition of the invisible labor people with disabilities perform to navigate systems not designed for them. Ultimately, I argue that navigating this particular process is akin to how people play games– a practice that we have long studied that we might leverage for additional insight into how to better support this process.

Across my dissertation, I aim to demonstrate the following thesis statement: Analyzing disabled technology adoption with a lens of game design can reveal new opportunities for both designing and leveraging access technologies.

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Acknowledgments

A *perpetual stew* is a dish that is continuously added to while also being enjoyed, with new ingredients added over time, evolving the flavor based on what it needs at any given point. And for the sheer ridiculousness of the comparison, I am so delighted to thank everyone who has contributed to my stew up to this point.

Even before grad school, there were people who contributed ingredients to the stew which I still embrace today. At the University of Chicago, I was taught how to appreciate the art of games, and given the amazing opportunity to develop my own game artistry. Much thanks to everyone involved in that area, in particular my incredible mentors Patrick Jagoda and Ashlyn Sparrow. I was also exposed to the incredible range of what computer science, HCI, and research could be, from so many mentors at UChicago CS, with particular thanks to Blase Ur and Pedro Lopes.

I'll be honest, I'm still a little shocked that my stew made the menu at UW, but after years of confirming it wasn't a clerical error, I suppose I can finally accept it. My incredible advisor, James Fogarty, has been so dedicated to getting me where I need to be from the very first day. Thank you for seeing something in me, encouraging me when I most needed it, and challenging me to always keep growing and pushing myself. I'm very excited to find my own voice as an advisor some day, but I expect I'll find myself quoting you often– at the very least, by starting my advising meetings by asking "what's useful?"

I have also benefitted from such incredible mentorship and academic support throughout my

time at UW. The list is certainly too long to fully capture here, but I am so grateful to Jen Mankoff, Brennen Johnston, Tony Fast, Jin Ha Lee, Jon Froehlich, Julie Kientz, Elise DeGoede Dorough, Chris Nagle, and Joe Eckert for all their support over the years. Thank you all for your teaching and guidance in what makes a good stew, for tasting it along the way, and whatever other silly soup euphemisms feel right here.

And of course, a soup is no good without friends to enjoy it with. So much of the support that has gotten me through these last seven years transcended beyond the academic pantry into genuine love, care, and friendship. I can't imagine making it through without my combined neighbor-labmates Aashaka Desai, Avery Mack, and Emma McDonnell– frankly, navigating accessible game nights really gave my stew the perfect base to build from. Thank you all for helping me figure out just what flavor of researcher and human I'm trying to be.

On a similar level of absurdity to discussing stews in a dissertation, getting to play games and goof off with world-class researchers has also been one of the true joys of my PhD experience, and I'm so, so grateful to the incredible community I've gotten to play with at UW. Enormous thanks to my labmates, collaborators, co-conspirators, tenuous frenemies in games of mafia, "work from brewery" coworkers, and everyone else who constantly reminded me that games, laughter, and really bad jokes *do* have a place in academia.

And finally, I need to thank Noah Casner, who has played some of life's most complicated games with me and, for some reason, to my unending delight, keeps wanting to playing the game with me. And I guess sometimes that game is "express love and gratitude through haphazard, inconsistent comparisons to soup," but as you've pointed out, I most often express how happy I am while we're sharing a good meal– even if it's something as ordinary as a warm bowl of soup. Here's to many more soups, stews, and everyday joys over the years.

Chapter 1

Introduction

Let's play a game. This game is a lot like Rock/Paper/Scissors: on the count of three, we'll each choose whether to play Rock (which beats Scissors), Paper (which beats Rock), or Scissors (which beats Paper). The only difference from the traditional variant of the game is that I have to tell you, with complete honesty, which item I'm about to play. This time, I'm playing Rock.

One... Two... Three...

I played Rock, and, assuming you trusted my earlier statement, you probably played Paper and have won the game. Congrats! It's a terrible game, but hey, you still won.

Now, let's play a slightly different version. Once again, we're both picking Rock, Paper, or Scissors, and we'll play three rounds this time. In order to win, you need to beat me all three times. But instead of telling you what I'll play each round, you have the overall probability distribution of my choices, which is consistent across rounds: 60% of the time, I play Rock; 30% of the time, I play Scissors; and 10% of the time, I play Paper. The Game just got a lot harder to win, didn't it?

Now let's reframe this game to be about accessibility. Suppose the "player" in the game is a thirty-something with inflammatory arthritis who works at a small boutique. Her opponent is the set of work tasks she will need to do, which she cannot know in advance. In her experience, there

is a 60% chance she will be sitting behind the counter all day, in which case she can manage her symptoms subtly with compression socks; there is a 30% chance she will need to walk around the store, in which case she would want to bring her cane for a bit of support; and there is a 10% chance she will need to bend over or climb ladders to retrieve items from the stockroom, in which case she will want her knee braces and back brace.

Now play a lifetime's worth of rounds of "Sock/Cane/Braces": it's near impossible to always win, and it's definitely still a terrible game– just for different reasons this time.

* * *

When navigating accessibility challenges, people with disabilities are often forced to play a version of this terrible game[1], which I have come to term the "Game of Accessibility". Between deciding what access technology (AT) to leave the house with, estimating the likelihood of certain access barriers appearing, or calculating the trade-offs between variables like cost, safety, and social perception, the Game of Accessibility demands people with disabilities constantly cope with ever-shifting rules and complex strategic challenges, all of which makes it an extremely difficult game to play, let alone "win."

For both the disabled people who play the Game and the AT designers who create tools used in it, understanding the rules of the Game of Accessibility is extremely important. To expand and complement the ever-growing body of accessibility literature exploring how designers and technologists can best support people with disabilities in navigating access challenges, I have set out to conduct research that articulates the rules of this Game. Ultimately, the goal of this research is to support people with disabilities in more easily navigating the Game's challenges and support

[1]Though the initial examples have fallen neatly into the category of "games" per game theory and mathematical definitions, I primarily use this term in the broader sense it is used in the fields of game studies and game design, which will be further defined in Section 1.2.2.

AT designers and other stakeholders in better supporting disabled audiences in navigating this complex challenge.

1.1 Thesis Statement & Dissertation Overview

Across this dissertation, I aim to demonstrate the following thesis statement:

> **Analyzing disabled technology adoption with a lens of game design can reveal new opportunities for both designing and leveraging access technologies.**

In **Chapter 2**, I begin exploring this topic by reviewing prior work in HCI accessibility research, exploring the current state of game accessibility, and reviewing relevant topics from the field of game studies. This chapter lays the foundation for my discussion of *"disabled technology adoption"*, while also defining key concepts that inform the *"lens of game design"* I apply in my analysis.

In the three subsequent chapters, I present three research projects that were completed across the course of my PhD. Together, the findings of these three projects constitute the evidence I will use to demonstrate my thesis statement.

In **Chapter 3**, I present the findings of an interview study conducted with gamers with disabilities that explores the resources used, strategies employed, and challenges faced throughout the process of game adoption. This work begins the process of *"analyzing disabled technology adoption"*, and also discusses concepts such as metagaming and disabled gaming that later contribute to the overall *"lens of game design"*.

In **Chapter 4**, I present the findings of an interview study conducted with people with disabilities exploring the process of "modeling" accessibility– that is, the analysis and decision-making process performed when faced with an access barrier and deciding how to navigate it. Here we begin *"analyzing disabled technology adoption"* beyond the scope of games, and develop a

model of accessibility that helps *"reveal new opportunities for both designing and leveraging access technologies."*

In **Chapter 5**, I present the third and final project, which explores informational needs and processes employed by people with disabilities in the process of adopting new access technologies. This project also contributes to *"analyzing disabled technology adoption"*, with a particular goal of surfacing current challenges specific to access technology adoption, again setting us up to *"reveal new opportunities for both designing and leveraging access technologies"*.

I then build on the findings of the preceding chapters in **Chapter 6**, revisiting them in the context of my thesis statement. In Section 6.1, I first synthesize the key insights around disabled technology adoption from Chapters 3–5. In Section 6.2, I return to the concept of the "Game of Accessibility" to demonstrate the impact of applying a lens of game design in this space. In Section 6.3, I then present one potential implication of this analysis, another model for considering AT named the "Decision Tree Model of Accessibility". Finally, I conclude my dissertation by reflecting on the central takeaways of my work and proposing potential future directions for additional research.

1.2 Positionality & Other Considerations

1.2.1 On Disability & Language

Disability is, for many people and cultures, a sensitive topic to discuss, and a topic that people may carry strong preconceptions about. In Section 2.1, I formalize my working definitions of disability and accessibility, reflecting on various cultural models and how they relate to the goals of accessibility research and access technology design.

In short, I approach most discussion of disability using the "social model" [113], which frames

disability as a byproduct of a mismatch between society's expectations of how a person needs to operate and how a person actually navigates the world. A key consideration of this is that disability is not something bad or something to be "fixed". I also feel this definition actually characterizes the experiences of a much wider audience than those who generally self-identify as disabled– and as such, I attempt to frame my work to encapsulate a broad range of disabled experiences, rather than just the experiences of those who culturally identify as disabled. Of additional note is that as I have developed this understanding of disability, I have also come to understand my own identity as someone who is disabled by society, technology, and many of its systems, and thus some of my framing is certainly informed by my own experience navigating inaccessibility as a neurodivergent person who often operates in a "non-normative" way.

Additionally, there are varying opinions and individual preferences about how to discuss disability, which are unified in emphasizing the importance of intentionality in language. Across this dissertation, I use both identity-first language (e.g., "disabled person") as well as person-first language (e.g., "person with a disability"). When discussing specific participants in studies, I explicitly use whatever language the participant used to refer to themselves. However, outside these cases, I generally aim to use language that I have personally seen people from the relevant populations use when discussing their disability identity. This may include collective acronyms, such as PWD (person/people with disabilities), BLV/BVI (blind & low vision, or blind & visually impaired), d/DHH (d/Deaf or Hard of Hearing), as well as various cultural terms such as "neurodivergent" or "neurodiverse".

1.2.2 On Games

Additionally, I feel it is valuable to clarify my intentions when I discuss "games" throughout this dissertation, in particular the Game of Accessibility I center throughout. There are many different

perspectives on what constitutes a "game", including those formally defined by game studies scholars as well as more informal, everyday interpretations. In Section 2.4, I will more thoroughly define my operationalized conception of games. However, in its most basic sense, I consider a game to be **a system with a specific set of rules that influence how a person interacts, in a way that meaningfully differs from everyday behavior outside interaction with that system.**

This is, intentionally, an extremely broad definition of games, which falls somewhere between the traditional mathematical definition of a game and the common definitions used in game design from works such as Salen & Zimmerman's *Rules of Play* [139].

However, a key point I hope to emphasize is that my discussion of "games" throughout this dissertation is not meant to be flippant or reductive about the lived experience of people with disabilities. Suggesting that navigating constant barrage of access barriers is 'fun', or that navigating life with a disability can be 'won' would be reductive, disrespectful, and deeply inaccurate. Instead, I aim to use the language of games to enable a specific discussion and articulation of the experience of navigating access barriers and engaging with technology with a disability.

Chapter 2

Background

2.1 Accessibility: Relevant Theory & Frameworks

2.1.1 Fundamental Models of Accessibility & Disability

Within the world of accessibility research, there are a variety of different framings and models used to characterize disability, (in)accessibility, and how disabled individuals interact with the world.

Within my work, I predominantly use the "social model" framing of disability, which characterizes disability primarily as a mismatch between what a person can do and what society (and its material manifestation) expects them to be able to do [113].

This contrasts against various other models of disability, most notably the "medical model", in which disability is generally framed as a limitation of a person and their bodymind to function a certain "normal" way. This model, though still used in some contexts, is known to overemphasize the goal of "fixing" or "normalizing" a disabled person as a primary means of addressing inaccessibility. This framing becomes particularly ineffectual as we discuss Access Technologies, which often

exist outside the body and include infrastructural features (e.g., ramps and curb cuts) that do not change a person but do change their ability to navigate the world effectively.

Another relevant attribute of the social model of accessibility is its emphasis on accessibility as a collaborative societal goal, rather than a consideration only for a portion of the population. By framing disability and inaccessibility as a mismatch between a person's abilities and the requirements of a context, it becomes something that a much broader population can work to address: anyone can install a ramp to address inaccessibility for a person using a wheelchair, rather than the onus being on the person in a wheelchair to find some way to go up stairs. This again becomes particularly important in the context of AT: technology designers have a much broader design space when they can consider ways to address barriers in the environment or context alongside tools to enable disabled people to do new things.

One other prominent model is the *postmodern* model of disability [112], which notably varies from the medical and social models in its centering of *who* is disabled and *how* (as opposed to focusing on *what* disables a person). The postmodern model pushes against attempts to classify "types" of disability, and in particular emphasizes an opposition to the premise of a "normal" body, particularly as it is used to characterize an "abnormal" one. This model has significant ramifications within the context of disability justice and human rights [11], and generally does not directly clash with the premise of the social model. However, I choose to center the social model in my work for its discussion of systemic oppression that produces inequity (i.e., disability), which is necessary for understanding how we might create new tools and systems to counteract this oppression.

However, in addition to having functional models of how we define disability, it is imperative that we also consider the cultural role of disability and account for that in our discussion. Although I will not claim to understand an entire culture's experience, I do feel there are a few fundamental principles of disability culture and disability justice that are critical to discuss here.

The most important principle to emphasize, from my perspective, is that disability is not fundamentally "bad" and ought not be approached as something to "fix" or "avoid". As an intrinsic part of many people's identity and lived experience, disability is something that people have deeply complex personal relationships with and that has influenced culture at micro and macro scales. Plainly, no culture ought to be erased– and we must be careful to disentangle goals of reducing undesirable societal inaccessibility from the concept of eradicating disabled identities.

Relatedly, it is important that the onus to address accessibility problems in the world not be placed entirely on people with disabilities. As emphasized in prior discussion of the social model, inaccessibility exists as a byproduct of society and the world we have all built, and therefore it ought to be the responsibility of those who created the inaccessibility (i.e., society writ large) to address it, even if they are not directly affected by it.

And finally, I want to emphasize that disabled people are not a monolith, and many disabled people have drastically different goals from each other and have different relationships to disability, society, and so on. Throughout my dissertation, I strive to approach the topic of accessibility through a lens of 'how can we support disabled people in having more independence, by minimizing the extent to which society dictates what they can or cannot do?' However, there are entire communities and countercultural movements built on the premise of *wanting* to exist outside "the norm", actively embracing what makes people different, and celebrating friction between individuals and societal structures. To say all disabled people want what I want would be a fallacy– and I celebrate this difference while still feeling justified in my framing and approach.

2.1.2 Complicating Accessibility: Additional Frameworks and Models

Beyond the fundamentals of accessibility and disability, there are many additional framings and models that productively complicate and add nuance to how we approach accessibility in research.

Some of these models have begun to characterize the social and interpersonal facet of accessibility, prompting us to consider accessibility as more than just an interaction between *one* person and a given context.

Shinohara et al. [145, 146] proposed designing for **social accessibility**, extending tenets of the social model of accessibility to emphasize the importance of considering how access technologies work in a complex, social world, rather than imagining them in abstract isolation. This framework also emphasized commonly overlooked implications of using access technologies, such as signaling disability and complicating the expectations of interactions between PWD and nondisabled individuals.

Bennett et al. [8] introduced a framework for considering "interdependence" in the design of access technologies, building on long-standing disability justice principles (e.g., [74]) that emphasize that disabled people ought not be required to navigate the world in isolation. This framework surfaces an important tension in designing for accessibility: while it is often desirable to enable disabled folks to act independently (i.e., without *needing* to ask others for support), it should not be assumed that in all settings a person would rather, say, use a particular technology instead of ask for support.

Relatedly, Hofmann et al. [69] have added further nuance to the accessibility research community's understanding the complexity of social dynamics in accessibility, expounding upon the premise of access conflicts, in which access goals of multiple disabled people may not always be aligned. Particularly when considering multiple different disabilities and sets of access needs, there is not necessarily a single solution that works for everyone– so in considering designing for accessibility, it is critical to consider intersections of disabilities alongside considering particular standalone access needs.

Additional work in intersectional accessibility has also explored the role factors such as race [63, 35, 9], gender [9], and queerness [35, 9] play in how PWD navigate accessibility challenges,

further emphasizing how there are few "universal" approaches to accessibility.

One final relevant framework is Mack and McDonnell et al.'s conceptualization of "consequence-based accessibility" [99]. The framework pushes back against certain existing notions of accessibility as a binary 'accessible vs. inaccessible' to introduce the wrinkle of actions that *can* be performed, but that later have consequences for the person performing them. Of particular note is their initial formulation of "consequence calculus", which begins to characterize how a disabled person might decide whether or not to engage with an access barrier. Though originally presented within the context of better considering chronic illness in accessibility, the framework has wide-ranging impacts, as other researchers have come to recognize that navigating an access barrier may come with consequences (e.g., [93, 72]).

2.1.3 Adaptation & Access Hacking

"Access hacking" is an important practice in disabled communities, generally describing the act of creating and modifying tools, infrastructure, and social practices to navigate systemic inaccessibility. Hamraie and Fritsch's *Crip Technoscience Manifesto* [62] formalizes many details of this role of people with disabilities as knowers, makers, hackers, and designers, and points to current issues and failings within accessibility research that does not consider the existing work that people with disabilities do to overcome access barriers. Within HCI accessibility research, access hacking has been explored in many different contexts, often framed around the "strategies" and "tools" employed by PWD for navigating inaccessibility.

Returning to the crip technoscience characterization of PWD as "knower-makers" [62], the process of physically manifesting hacks is integral to access hacking culture, which has led to significant connection to the DIY/"maker culture" movement. A significant portion of access hacking research in HCI has focused on "maker culture", centering (generally) low-cost, consumer

tools and DIY approaches to accessibility. Maker culture has enabled many different types of access hacking, including both making brand new DIY AT [25, 73, 104] and modifying existing tools [28]. This work has also documented the variety of tools used for creating AT, including 3-D printing [28, 107, 104], knitting and fabric arts [84, 159, 160], and electronics prototyping [142, 45].

This work has also characterized the role that social relationships play in hacking access. Maker communities have embraced accessibility and access hacking in a variety of contexts including online communities [25, 54, 118], makerspaces [66, 152], classrooms [26, 27], and clinical settings [68, 71]. These communities are integral to the process of access hacking, providing support across multiple phases of the process including design [28, 65, 147], production [118, 71, 36], and evaluation [25, 68]. This community focus complements social models of accessibility (discussed above) that position interpersonal relationships as key components of holistic accessibility.

2.2 AT Adoption & Abandonment

While a large body of research has explored the design of AT, there is much less research studying *why* PWD adopt the tools they use. One model of AT adoption frames the process as a four-stage cycle of [AT] Development, Selection, Learning, and Integration [88], with each stage presenting its own factors that may cause a person to abandon a particular technology. Potential evaluation factors include cost, perceived usefulness, complexity and perceived burden of use, and social perception, all of which have been validated in subsequent work [116].

Additional exploration of AT adoption and abandonment cites the disparate objectives of stakeholders as a key reason AT users may abandon technologies or find their AT does not suit their needs [141]. This work posits that, while AT users prioritize comfort and function as key success metrics, other stakeholders such as physical and occupational therapists may disregard those priorities in favor of more success-oriented metrics such as bodily ability and task

performance.

The fields of occupational therapy (OT) and rehabilitation medicine play very significant roles in AT acquisition, with many PWD turning to specialists in these fields for support in finding the right AT. In HCI accessibility research, this relationship has been explored in the context of DIY AT [147, 71], but very little work has explored the role of sociotechnical systems in other interactions between OTs and PWD regarding AT acquisition and adoption.

2.3 Game Accessibility

The burgeoning field of game accessibility research has begun to explore the space from a variety of directions. Early formative work was primarily focused on enumerating the many types of access barriers found in games (e.g., [2, 14, 163]). There has also been work that takes a design-first approach to this topic, in some cases through the design of specific accessible games (e.g., [162, 31, 110]) and in others through directly adapting games [134, 162] or controllers/input devices [162, 157, 52, 31, 3].

As the gaming industry has grown, many researchers have begun proposing design recommendations for game developers [23, 125, 43, 163]. Resources for developers have also begun to receive attention outside of academia, with initiatives such as the Game Accessibility Guidelines [1] and Xbox's Game Accessibility Guidelines [87] providing explicit tools for game designers and developers to use.

More recently, game accessibility research has emphasized the importance of understanding the experiences of disabled players, exploring topics like the affective experience of playing inaccessible games [130, 135, 125, 53, 5], techniques used for navigating access barriers in games [53, 127, 134], and how people with disabilities employ games for other access goals [132, 81, 34]. Limited work has explored the relationship between theoretical game studies concepts and accessibility.

Prominent game accessibility advocates have engaged in some theorizing about difficulty and accessibility: Hamilton has distinguished difficulty and accessibility by characterizing difficulty as "capability vs. barrier" and accessibility as "avoiding unnecessary mismatch between capability and barrier" [60], and Johnson has introduced the concept of "friction that fits" as an articulation of what accessible game difficulty can feel like [82]. Very limited work has sought to bridge the "game" and "non-game" areas of accessibility research. This has occasionally occurred when researchers design games as research tools in an accessibility-related domain, such as designing educational learning games [34] or fitness "exergames" [44, 102, 129], which are often related to rehabilitation medicine and physical therapy.

2.4 Relevant Game Studies Concepts

2.4.1 Defining a "Game"

A widely used definition of a game, from Salen and Zimmerman's textbook *Rules of Play*, defines a game as "a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" [139].

However, games also have a longstanding history in mathematics, and the aptly named field of game *theory* (which I differentiate from the media studies practice of game *studies*). Within the space of game theory, a game is often understood to be a specific strategic interaction with multiple players and objectives. One foundational definition characterizes a game as: "a description of strategic interaction that includes the con- straints on the actions that the players can take and the players' interests, but does not specify the actions that the players do take" [115]. Though I primarily use a game *studies* framing (rather than a game *theory* framing) throughout this dissertation, there are a handful of instances where I specifically invoke mathematical games for

particular kinds of analysis.

To operationalize what we mean by "game" in the context of this dissertation and discussion of the Game of Accessibility, there are a few key attributes necessary to clarify to distinguish this definition from everyday understandings of a game:

1. **Games are not necessarily fun or desirable.** In contrast to ludic definitions of games that center recreation, leisure, and playfulness, this framing of games does not require "fun" to be a relevant consideration for any players. However, there is often a particular objective or goal the "players" work towards, such as comfort, efficiency, or some form of satisfaction. This understanding of games is sometimes used in other contexts where games are used to describe a complex system, such as war games, serious games, "the dating game", and so on. This is also consistent with mathematical games, which are defined by a variety of objective metrics, seldom including "fun".

2. **Games are not necessarily separated from other systems.** In some games, there is a clean articulation of who is playing and what the accepted rules of engagement are: for instance, at a poker table, it is widely understood that the seated players are the only ones playing, and that it is socially acceptable to try to deceive the other players. This is often described as the "magic circle" of play [139], delineating the boundary between the game and the "real world". Other games, particularly some "everyday" games, do not have a clear articulation of who is playing, nor which "rules" various people are playing by. For instance, a *Pokémon Go* player may have an atypical goal at a local park (e.g., as described in [13]; and someone playing a game of economizing at the supermarket via coupons might care more about which brand they buy than another shopper.

3. **Not all games can be "won", and there are various metrics of relative success.** Salen & Zimmerman's traditional definition specifies that a game must have a "quantifiable outcome",

and similarly, mathematic games typically center an end state where players' outcomes are assessed. However, both of these framings center an end state as the primary metric of success; meanwhile, I would argue that success in some games is more aptly defined by performance during the game, rather than final outcome. For instance, consider a high school basketball player whose metric of success more actively centers how he showcases his skills for a college talent scout than the actual performance of his team. This can also be understood to mean that **different players may have different success metrics**, which further complicates the concept of a "quantifiable outcome". This is occasionally seen in "asymmetric" multiplayer games, where different players have different win conditions, such as *Betrayal at the House on the Hill*, versions of *Werewolves* or *Mafia*, and so on. However, in these cases, there is still a specific determination of whether a given player has won or lost by the end of the game.

2.4.2 Difficulty, Demand, Challenge

Central to Salen & Zimmerman's definition of a game [139] is the premise that all games have some amount of conflict or "challenge". To better describe challenges in games, scholars have developed varying definitions of "difficulty" and "demand" that characterize certain aspects of the experience of engaging with a challenge.

Jagoda's definition of difficulty is centered around what a game challenge requires a player to do, and how much effort that challenge will take [77, 78]. He also introduces three distinct types of difficulty, which help provide a more nuanced understanding of how games challenge players. Mechanical difficulty characterizes how games test physical abilities and reflexes; interpretive difficulty characterizes the logical and cognitive challenges in a game; and affective difficulty characterizes how games require navigating a broad range of emotions. Though similar to

difficulty in many ways, demand is a distinct descriptor of game challenges that is centered more on what the player feels, rather than what the game requires. Bowman et al. have explored this concept extensively (e.g., in [18, 20, 47]), leading to the development of the Video Game Demand Scale (VGDS) [20], which further defines the nature of "demand". The VGDS highlights five key dimensions of demand: Cognitive Demands, describing the demand of problem solving; Emotional Demands, describing the demand of processing emotions; Controller Demands, describing the demand of interacting with a device/controller; Exertional Demands, describing the physical and mental demand of responding to game challenges; and Social Demands, describing the demand of interacting with others through play. These demand dimensions provide additional useful vocabulary for describing player experiences, but although there has been significant work to validate the VGDS across varying cultural contexts (e.g., [47, 89]), it is worth noting that the VGDS has not explicitly been validated in a disabled gaming context.

2.4.3 The Space of Possibility

Another central concept from games studies is the idea of "the space of possibility": a term used to describe the indirect relationship between a game designer's system and the player's gameplay experience. In *Rules of Play*, Salen and Zimmerman introduce the concept:

> Game designers do not directly design play. They only design the structures and contexts in which play takes place, indirectly shaping the actions of the players. We call the space of future action implied by a game design the space of possibility. It is the space of all possible actions that might take place in a game, the space of all possible meanings which can emerge from game design. [139]

In essence, the space of possibility delineates the role player agency and action has in defining an interaction with a system. In the context of games, this can be highly variable, as players can

have very different objectives when playing a game. Open-ended games like *Minecraft* can present many different paths forward for the player to choose between. But even in narrower games where there is effectively just a single path forward, players can approach it with different goals, such as trying to complete the game as quickly as possible or collecting all the secret trophies.

As introduced, the space of possibility is explicitly about play and game design; however, when applied to other interactive systems, we can see how the design of any interactive system presents its own space of possibility. Users with the same objective can also reach it in differing ways, informed by both the system design and their personal preferences. For instance, a Photoshop user attempting to remove something from the edge of a photo might opt to crop the photo if they don't care about changing the image size, or they might manually select the item and recolor the region to preserve image size at the expense of "authenticity".

Within the context of the Game of Accessibility, we can use this framing of the Space of Possibility to articulate the interactions and outcomes that could, in theory, exist in a particular player's journey through the game. We explore the complexity of this application in detail in Section 6.3.

2.4.4 Metagames and Non-Normative Gaming

Relatedly, games scholars have also explored the concept of the "metagame", which, in its most basic, etymological definition, is a "game about a game" or "game beyond a game". The exact form and characteristics of a metagame can vary wildly, but at their core, metagames involve interactions with a game beyond what is specified within the core rules of the game. *Magic the Gathering* creator Richard Garfield provided an early categorization of types of metagames [49], distinguishing metagames defined by:

- *What you bring to a game*, e.g., reputation or strategic planning

- *What you take from a game*, e.g., a prize, an experience, or changes to social standing with other players
- *What happens between games*, e.g., strategizing with other players or practicing skills
- *What happens during the game (other than gameplay)*, e.g., trash talking, taking timeouts, or game-adjacent activities like socializing during a murder mystery party

In Boluk & Milieux's *Metagaming*, our definition of a metagame is further complicated, in part as the authors tease apart the difference between explicit "rules" and implicit "mechanics" of a designed game:

> Unlike traditional games in which voluntary rules are consciously chosen to further constrain or interpret the physical properties of dice and cards...videogames conflate the rules of a game with the mechanics of the equipment. [16]

Through this lens, we can begin to understand a player's role in defining what the game actually is and what rules dictate their play. There are common, widely-accepted rulesets, such as trying to come in first place in a racing game like *Mario Kart*, which are also often reinforced by the game's feedback systems (e.g., *Mario Kart* shows celebratory scenes upon winning the race and may allow players to unlock new game elements). There are also socially-defined and community-defined metagames with broadly accepted alternative rulesets, such as house rules for playing *Uno* or customized online *Minecraft* servers that introduce new game elements or digitally enforce rules like no player-vs-player combat.

Then, we also have individual metagames, where players decide for themselves how they want to interact with game mechanics. This might include decisions about how to play a game *within* the widely-accepted ruleset (e.g., choosing whether to play as an archer or swordsman in *Skyrim*), creating new individual objectives (e.g., beating a *Legend of Zelda* game without ever being hit by

an enemy), or eschewing the game's presumed rules to play a very different game (e.g., ignoring the racing structure in *Mario Kart* to use the game as a world-exploration simulator).

Implicit in this definition of metagames is rationale behind *why* someone opts to play a game a certain way, particularly in cases when they approach the game in a non-normative way. In many cases, it is "easier" to play a game as intended, which suggests there may be underlying motivations that drive a person to play in a way that defies norms.

Various authors have explored "non-normative" approaches to gaming. One major research thrust has explored antisocial and trolling behaviors (e.g., [19, 33, 155, 67]), seeking to articulate why players might go out of their way to subvert and violate socially established rules of play. Collectively, these studies have identified a variety of motivations, including self-defense, processing feelings of exclusion, and revenge responses to individuals or groups. Whatever their reason, trolls demonstrate how a person's individual identity and relationship to a community can fuel them to devise and employ alternative play styles. This also ties into the concept of "deviant gaming", which authors such as Kishonna Gray have explored in detail, particularly as it relates to race and gender [55]. Similar to trolling, deviant gaming involves intentionally defying societal norms in one's play, though often this has a more actively malicious undertone that tends to be more directed and *ad hominem* than typical trolling, often rooted in enacting racism, sexism, and other discriminatory ideologies. In this sense, deviant gaming is generally less oriented around being an 'insider acting out', and is more related to being an 'outsider entering in' (i.e., entering a space they did not previously occupy for the primary purpose of violating social norms).

Finally, we can connect this to the practice of 'identity-driven gaming', which characterizes how certain (typically minoritized) identity groups develop distinct ways of engaging with a game, sometimes in active defiance of norms, and other times in pursuit of creating new norms or in-groups. Bo Ruberg et al. have explored this in the context of queerness (e.g., in [137, 29, 138]), highlighting how queer gamer communities (re)interpret game content through a queer lens,

regardless of whether the designers intended their game to engage with queerness [137]. Similarly, other scholars have also taken this perspective in understanding how race relates to player behaviors (e.g., [57, 58]), how gender (particularly for women) affects approaches to gameplay (e.g., [140, 59]), and how intersections of identity groups complicate this experience even further (e.g., [140, 57]).

Ultimately, this body of work has established that people vary widely in how they approach a particular game, and that an individual's gameplay can be heavily influenced by identity, contextual factors, and past experiences. Extending this into the Game of Accessibility, we can keep in mind how people might vary in their gameplay approach and goals, and we can seek to identify similar factors that influence how a person attempts to "play" this game.

Chapter 3

Playing on Hard Mode: Accessibility, Difficulty, and Joy in Game Adoption for Gamers with Disabilities

In exploring the intersection of accessibility and games, we can first start by coming to understand some of our higher-level themes– technology adoption and complex decision-making around accessibility– in the smaller-scale domain of gaming. This work was published at CHI 2023 as *Playing on Hard Mode: Accessibility, Difficulty, and Joy in Game Adoption for Gamers with Disabilities*, and was written with my Qualifying Exam committee members, Jon E. Froehlich and James Fogarty. I led all parts of this project, guided by my co-authors throughout analysis and writing.

3.1 Introduction

Video games are increasingly a part of everyday life and culture in our society, but they are too often designed without people with disabilities in mind [125, 163]. Nevertheless, many people with disabilities engage with video games, whether by searching for games that meet their access needs or by coming up with ways to modify inaccessible games to overcome accessibility barriers.

Recognizing the significant work that gamers with disabilities currently do to navigate the games "ecosystem" (i.e., encompassing everything from video games themselves to the distribution platforms and communities surrounding them), we sought to better understand existing processes related to finding games to play and getting set up with a new game—a process we term *game adoption.* We adopt and adapt Lee et al.'s model of "*discovery, access, and organization*" [91] of information about video games to construct a three-phase model of game adoption, consisting of:

- the **Discovery Phase**—the task of finding a game one might want to play;
- the **Evaluation Phase**—steps taken to evaluate whether a game meets a player's personal criteria, including access needs;
- and the **Adaptation Phase**, where players learn to play a game and develop their playstyle, including developing solutions to access issues.

In this model, Lee et al.'s process maps onto Discovery and Evaluation. We introduce Adaptation as a third phase that has received less attention in HCI research, but has been explored in game studies literature as "learning" and "specialization" behaviors [139, 16]. We use these phases to scaffold our exploration in part because each phase has clear objectives for a general audience (i.e., including nondisabled individuals) as well as specific goals for disabled gamers. We present examples of these goals in Table 3.1. Through better understanding game adoption processes among gamers with disabilities, we aim to identify key challenges and opportunities

	Discovery	Evaluation	Adaptation
General Goals	• Identify candidate games that one might be interested in playing • Learn basic information about the game	• Gather additional information needed to assess if the game meets one's preferences/criteria	• Learn how to play the game • Identify preferred playstyle • Decide whether to continue playing or abandon
Added Access Goals	• Identify games that *might* be accessible	• Identify potential access issues • Determine if game could be "accessible enough"	• Develop & implement solutions to address access issues

Table 3.1: The three phases of the game adoption process and their related objectives. During Discovery, players seek to identify games they may be interested in playing. During Evaluation, players gather additional information about a game and assess whether they are interested in playing it. During Adaptation, players learn the game and develop their personal style of playing it, including developing relevant workarounds to access barriers.

that arise during this process that can inform future research in the accessible gaming space, as well as to advise game developers and distributors on how to take the burden off the gamer and better support their gameplay.

To explore these topics, we conducted an interview study with thirteen gamers with disabilities discussing their current game adoption practices and challenges they encounter therein. We analyzed our interview data using reflexive thematic analysis [22] to surface insights related to each phase of the game adoption process, discussing barriers participants currently face, the work already performed to navigate these barriers, and the utility of various features in the games ecosystem in supporting the adoption process.

We then consider disabled participant experiences with game adoption in conversation with existing literature around conceptual organization of games and "hacking" accessibility. We also

engage with key theoretical frameworks from games studies to develop a deeper understanding of how the gameplay experiences of gamers with disabilities might differ from existing understandings of game experiences. Specifically, we (1) introduce the concept of "access difficulty" in games and explore how it relates to existing theories of difficulty and conflict in games as constituted by the work of various scholars including Salen & Zimmerman [139], Jagoda [78, 77], Bowman [18, 20, 89, 38], and Hamilton [60]; and (2) use the lens of identity-based gaming, as instantiated in Gray's exploration of black gaming [55, 58, 57, 56] and Ruberg and Chang's exploration of queer gaming [137, 29], to deepen the understanding of experiences of gamers with disabilities and "disabled gaming." We also briefly explore our findings using the lens of consequence-based accessibility [100].

Finally, based on our findings and analysis, we contribute a set of actionable design recommendations for game developers, publishers, and distributors to improve the experience of game adoption for gamers with disabilities through engagement with community-made resources, through supporting socially-created access, and through augmenting games with opt-in features, customizable experiences, and opportunities for unconventional play.

3.2 Related Work

Video Game Discovery & Evaluation

Our work also explores how video gamers with disabilities discover and evaluate games. Prior work in this area includes Lee et al. who conducted an interview study explicitly exploring the topics of user discovery, access, and conceptual organization of video games [91]. They highlight the variety of metadata individuals want when discovering and evaluating games, ranging from high-level genre information to more detailed information about game content, such as if it contains mature

language, if it contains educational content, or if the content is geared towards underrepresented demographics in the gaming community. Although other work has explored how people use social media posts and online gaming communities to discover games [15], such work has not had an accessibility focus. We address this by exploring how these discovery strategies and more are utilized by gamers with disabilities in their game discovery process.

3.3 Methods

3.3.1 Interview Process

We conducted a semi-structured interview study with thirteen gamers with disabilities. The interview started with a discussion of each participant's disability, background, and general experience and relationship with games. Then we asked about three main topics: how to find games to potentially play ("Discovery"), how to assess if a game was a good fit for them, including whether it meets their access needs ("Evaluation"), and how (if at all) they adapt games or change their play style to navigate accessibility barriers ("Adaptation"). When discussing each of these three topics, we specifically set out to identify three key aspects of the participant's process: what *resources* a person uses or opts not to use, what *strategies* they employ, and what *challenges* they face along the way. These aspects generally arose naturally through discussion of their approach to each phase, but additional follow-up questions were asked as needed. Finally, the interview closed with several debrief and reflections questions, including a discussion of what developments participants would most like to see related to accessibility in the games ecosystem.

We recruited participants online, including public posts in gamer communities and for people with disabilities, such as Reddit's r/DisabledGamers subreddit. Given our holistic, cross-disability focus, we did not target any specific disability groups. Instead, our recruitment criteria was

"anyone with a disability, chronic illness, or mental health condition that affects how they interact with games, as well as people who are d/Deaf and Hard of Hearing."

See Table 3.2 for brief profiles of the thirteen participants, including demographics, disability identity, and gaming practices.

All but one of our sessions were conducted as one-on-one interviews with participants on Zoom. Our session with Dylan, who is nonverbal, was conducted as an in-person interview with two family members who act as his aides, paired with an interactive observation of a gameplay session. The two interview transcripts and the interviewer's notes on the gameplay session were then included in analysis. We found this modification to be necessary to include this participant's perspective in the study, and believe this process produced a response comparable to our other interviews. This modification was developed on the recommended practices of adjusting a study protocol to a disabled participant's needs [98] and thoughtfully considering the role a proxy plays in research with people with disabilities [96].

3.3.2 Analysis

We analyzed interview data using reflexive thematic analysis [22]. We take a constructivist approach to analysis and utilize a critical lens, leveraging participant lived expertise to analyze the 'games ecosystem' as a complex sociotechnical system. We adopted a combined deductive-inductive approach to coding. Deductive codes were defined according to our framing model's three phases of Discovery, Evaluation, and Adaptation, as well as our three high-level research focuses on "challenges", "resources", and "strategies". Crossing each phase code with each focus code yielded a total of nine sub-codes ("Challenges in Discovery", "Resources for Evaluation", etc.). Additional coding was inductive and employed an open-coding approach. This round of coding was primarily focused on identifying meaningful experiences participants had with the

ID Pseudo	Select Demog.	Profile
P1 Dylan	Caucasian Male Aged 18-29	**Dylan** is autistic, has ADHD and several developmental disabilities, and is nonverbal and non-reading. He primarily plays games with his brother or aide on his iPad or Nintendo 64.
P2 Blue	Caucasian Genderqueer (they/them) Aged 18-29	**Blue** is disabled by chronic illness and experience chronic fatigue and other symptoms triggered by overwhelming visual motion, physical exertion, and other triggers. They seek out games with steady camerawork, which they play on PC and Nintendo Switch.
P3 Ken	Asian Male Aged 18-29	**Ken** has hemiplegia and tremors on one side of his body, and a speech impediment resulting from partial facial paralysis. He primarily plays online multiplayer FPS games on PC, and uses a programmable mouse for gaming.
P4 Aaron	Caucasian & Hispanic/Latino Male, Aged 18-29	**Aaron** is legally blind and uses text-to-speech and screen magnification when gaming. He primarily plays multiplayer FPS games on PC.
P5 Kristina	Asian & Latina Female Aged 18-29	**Kristina** is autistic, has ADHD, OCD, Auditory Processing Disorder, and chronic PTSD that can be triggered by graphic game content. She plays story-driven games on PC and usually enabled closed captioning when available.
P6 David	Caucasian Male Aged 40-49	**David** is colorblind and primarily plays on PC with color-identification tools. He tends to avoid real-time games, and enables color adjustment settings in games when available.
P7 Caleb	Caucasian Male Aged 30-39	**Caleb** has partial hemiplegia from a stroke, which limits use of his left hand while gaming. He primarily plays action/adventure games and plays on multiple platforms with AT including an Xbox Adaptive Controller with foot pedals and a modified one-handed PS5 controller from The Controller Project [90].

Table 3.2: **Participant Profiles.** Each Profile summarizes information shared by the participant about their personal identity and their relationship with video games, including game and platform preferences as well as selected details of their disability that were discussed in the interview. (Table continued on the following page.)

ID Pseudo	Select Demog.	Profile
P8 Mira	Caucasian (she/they) Aged 18-29	**Mira** is disabled by chronic illness that causes symptoms including chronic pain, fatigue, brain fog, dizziness, and audio & visual processing challenges. They also have ADHD, which causes executive dysfunction & trouble focusing, and cPTSD that can be triggered by sensitive game content. They seek out "action-packed" games with compelling visual style, which they play on Nintendo Switch or PC.
P9 Erich	Caucasian (he/they) Aged 50-59	**Erich** has psoriatic arthritis that affects their manual dexterity and keyboard/controller usage, and avoid games with topics that might trigger their depression or anxiety. They primarily play on PC, Playstation, and iOS.
P10 Avi	Asian Male Aged 18-29	**Avi** is congenitally blind and primarily games on iOS using Voiceover (when available) and screen recognition when a game lacks built-in Voiceover compatibility. He also occasionally plays multiplayer games on console with friends.
P11 Eddy	Caucasian Male Aged 40-49	**Eddy** is disabled by a condition that has affected the development of his hands, resulting in access needs around manual input and dexterity. He uses a variety of custom AT including a 3D-printed wrist mount for his specialty gaming mouse, and an Xbox Adaptive Controller. He is a Twitch streamer, plays on various desktop and console platforms, and plays a wide range of games including FPS, adventure, and roleplaying games.
P12 Marc	Caucasian Male Aged 18-29	**Marc** is blind and has ADHD, and plays on a variety of consoles. He uses a screen reader when available, and otherwise navigates games auditorially. He is a Twitch streamer, and often plays games while engaging with his streaming audience.
P13 Tristan	Caucasian Male Aged 30-39	**Tristan** is is deaf-blind and uses various AT including a cochlear implant, text-to-speech, and screen magnification. He plays FPS and RPG games on PC, Nintendo Switch, and Android.

game adoption process.

Braun & Clarke's reflexive approach to thematic analysis emphasizes the researcher's subjective perspective in analysis. Our analysis was primarily oriented around an awareness of the everyday labor people with disabilities perform to make gaming experiences more accessible, as well as an understanding of the limitations of traditional HCI frameworks to fully describe these experiences.

As part of our analysis, we also developed design recommendations for third parties, including game developers and distributors, regarding how to better support people with disabilities in game adoption. We fully present these recommendations in Section 3.5.5, and we surface specific details that informed these recommendations throughout our Results.

3.4 Results

We organize our analysis around the three-phase game adoption process. Within each phase (Discovery, Evaluation, and Adaptation), we explore the strategies, resources, and challenges participants described. We then explore two cross-cutting themes that emerged in inductive analysis: socially-created accessibility and appropriation for access .

3.4.1 Game Discovery

The Discovery Phase, in which participants sought to identify "candidate" games to potentially play, was a familiar process to all participants. Some participants engaged in Discovery more often than others, and approaches varied from highly involved, targeted searching to more passive, incidental learning about games.

Strategies & Resources Used

Participants primarily utilized social relationships, online communities, and game distributors during the Discovery process, and employed a range of strategies regarding how many games they aimed to discover.

Social Relationships. Most prominently, recommendations by friends were considered a reliable source for both content-based and access-based considerations: *"I'll just hear from my blind friends 'oh, this game could be playable!', but I never actually Google like, 'blind accessible games'—usually you just find out about them as they come out."* (Marc). Friends also made the Discovery process itself more accessible: *"I can get triggered pretty easily, so it's nice to have an information-seeking process that's guaranteed to not trigger me... [I ask] people 'hey, what do you think of this game, do you think that this would be interesting to me and worth my time to look into? [...] Or is it just going to be a disaster?"'* (Blue).

Some participants were introduced to games when friends invited them to play, but this did not necessarily imply the game would be accessible. Although Ken appreciated being introduced to the high-speed shooter *Valorant*, it did not bring him any closer to finding an accessible game: *"Theoretically, Valorant is a really fun game...I'm just not good at it. [...] I'm not doing most shooters, except for Valorant because my friends are into that and they make me play with them."* In other cases, friends introduced participants to games with a limited concept of how they might play it. Marc and Avi had sighted friends give them a hyper-specific role in a much larger game: Marc steered his team's ship in the sailing adventure game *Sea of Thieves*, and Avi's role was to rapidly mash buttons at specific points in the action racing game *Burnout Paradise*. Marc felt these recommendations did help with discovering new games and provided opportunities for enjoyable co-play, but Avi lamented that the games were still overwhelmingly inaccessible and these experiences were sometimes *"othering"* and *"not the same fun."*

Online Communities. Online gaming communities were often easy places to find new games. Some communities offered explicitly accessibility-oriented discussion, such as Reddit's r/DisabledGaming subreddit, disabled gamer Twitch communities, or the "game accessibility side of Twitter," centered around the accounts of prominent game accessibility advocates (e.g., participants specifically mentioned Caleb Kraft, Steve Saylor, Grant Stoner, and Tara Voelker in this category). In these communities, Discovery overlapped significantly with Evaluation, allowing participants to discover games with endorsements, warnings, and specialized information relevant to assessing accessibility. Gaming communities not centered around accessibility were still considered useful, as gameplay videos on YouTube and Twitch and publisher trailers were information-rich resources that provided additional context going into Evaluation.

Game Stores. Participants noted that although stores did not provide them reliable ways to search for games with accessibility as a primary focus, they learned to infer details about a game's accessibility from other channels. Ken relies on games having remappable inputs, but did not know of any mechanisms for searching for this feature. However, he learned that US- and Europe-based game studios were more likely to include this and other accessibility features than other studios, which he often used as a proxy in game stores.

Quantity of Games. Participants employed different strategies related to how many candidate games they sought to identify during Discovery. Some acquired large numbers of games, with limited consideration for whether the game would be a good fit for them. Avi and Mira both bought bundles of games when they would go on sale, in hopes that at least one game might fit their needs. David found a similar benefit in Xbox's "Game Pass Ultimate" subscription service, which provides a large library of games on various devices: *"I can play anything, anywhere. That's approachability [and] accessibility...for $15 a month. [...] To be able to [try] a lot of [Xbox's] games without putting out $500 or more is really cool".*

Other participants were more targeted, looking for games in specific franchises or genres they

already were familiar with. Although this approach produced fewer candidate games, they could already make initial accessibility judgments going into Evaluation. A couple participants shared that they seldom look for new games to play, in part due to the associated challenge of finding something that is actually accessible. For instance, due to a steep learning curve with new games and the lack of new games with the same sturdiness as the Nintendo64's plastic game cartridges, Dylan's family has not looked for new games since the console's discontinuation in 2002.

Challenges to Discovery

Though personal taste is a common consideration during Discovery [91], participants often felt they needed to choose between taste and accessibility. For some, personal taste was the primary guiding factor in the Discovery phase, deferring judgments around accessibility until later phases of the adoption process (e.g., these participants also generally prioritized finding a large number of games during this phase). However, for participants with relatively stringent access criteria, personal taste was forced to be a secondary consideration in Discovery: judgment on factors like genre or difficulty were deferred until after they had found a game and confirmed its accessibility. When asked what types of games he likes to play, Marc stated, *"I'll really play anything that's accessible– it's usually so limited to where I don't have a choice."*

Challenges also arose related to the visibility of certain categories of games. Indie games (i.e., games produced by independent artists or smaller games studios) were considered harder to discover than major studio games, which was problematic for Mira who found indie games had graphics that were less overstimulating than big-budget "AAA games". This was further complicated by *"false advertising"* of game visuals, where store advertisement art differed significantly from a game's actual visual style.

The Discovery process itself was also inaccessible at times. Many of the platforms used for Discovery had their own accessibility challenges: Marc highlighted Steam's poor screen reader

support, Mira and Kristina experienced ableism in online communities of certain games, and Kristina and Blue expressed frustration with missing captions and audio description in game trailers as well as triggering content in gameplay videos.

Design Takeaways

Our exploration of Game Discovery surfaced several key insights that informed our design recommendations:

1. Community resources play a core role in Game Discovery. Third-party content was frequently used (e.g., Twitch streams, game accessibility reviews on Twitter), but also sometimes considered difficult to find. This informed our recommendation to **Spotlight and Develop Community Resources.**

2. Game Discovery is also often a social activity, with participants turning to friends for recommendations and guidance on where to focus their efforts. This informed our recommendation to design for **Social and Independent Access Solutions.**

3. Participants also expressed that game stores often lack functionality to search specifically based on accessibility needs. This informed our recommendation for distributors to highlight **Opt-In Features and Customizability**.

3.4.2 Game Evaluation

Having identified candidate games in Discovery, participants then engaged in Evaluation, assessing these games for "fit". The predominant access goal in this phase was to gather additional information about a game needed to determine whether a game would be accessible to them (or at the very least, not *too* inaccessible to be dealt with during Adaptation).

Strategies & Resources Used

Participants primarily used four types of resources to evaluate a game's accessibility: peer, content-based, official, and contextual. We describe each below.

Peer Resources. Once again, recommendations from friends who knew a participant's access needs were considered the most reliable source of information. *"My accessibility needs are so really freakin' specific, it would be hard to find internet resources that have the information I need, versus my friends... they know all the kinds of things that trigger me so they know what to tell me about the game"* (Blue). Notably, this also circumvented the need to engage directly with a game's content, which participants with triggerable conditions like Blue and Kristina found particularly useful when evaluating games that could trigger their symptoms. Even if the friend did not feel equipped to make the final judgment, they could still offer useful information about potential concerns to consider.

Friends also sometimes provided direct access to games, enabling participants to watch or freely explore the game themselves without needing to purchase it first. Avi's local game store also served as this resource for him: *"I would go to the same store over and over... they would be nice to me and be like 'Okay, I have a console, if you want to just play and see and plan.' They didn't know accessibility, for them it's like... 'this customer is trying to play, let's be nice to this guy and let him figure things out.'"*

Community-Created Resources. Game online communities once again proved useful to participants. Twitch streams and YouTube gaming channels provided a valuable window into gameplay, which participants could use to inform whether a game would be accessible to them. As Ken described it, *"it's sort of like getting a free trial."* The interactive nature of these platforms also proved especially beneficial: Eddy would occasionally ask streamers to show specific game elements on their streams, such as the accessibility settings and game options for input remapping,

which were relevant to his evaluation. Eddy has also begun highlighting specific accessibility settings on his own Twitch streams, as he feels it is information that is often difficult to find.

Online accessible gaming resources, such as blogs CanIPlayThat [151] and DAGERSystem [150], allowed participants to evaluate game accessibility with a reasonable degree of confidence. Game reviews sometimes provided similar benefits: *"If [a reviewer] said something like 'oh, it was overwhelming', I might not buy that game simply because if it was overwhelming for **you**... that makes me believe it will be not enjoyable for me to play"* (Mira).

Official Resources. In contrast, participants only occasionally used content officially published by game developers and distributors during Evaluation. Trailers or official gameplay previews were often considered useful in understanding elements of the gameplay experience, particularly for games that had not yet been released or that did not have much community-created content, but these previews did not necessarily provide a comprehensive overview of the game experience. This proved problematic for some participants, such as Blue and Kristina, who found some trailers did not provide a sufficient sample of visuals and plot details from a game, sometimes surprising them with content that would trigger them when they actually played the game.

Contextual Resources. Finally, some players relied on contextual knowledge (i.e., also called 'relational metadata' [91]) about different game genres and franchises for their evaluation process. For some, this involved extending prior knowledge about a franchise: Aaron had played every game in the *Battlefield* franchise, and this provided a sense of confidence he could play the latest iteration, as he knew the core mechanics were accessible to him and would not change. Some participants identified patterns of access barriers across a particular studio's games, like Respawn Entertainment regularly requiring complex button combinations that were inaccessible to Caleb. This knowledge served as an additional filter during their search.

Challenges to Evaluation

Participants discussed three primary challenges that arose during Evaluation: the difficulty of finding specific game information, uncertainty around whether an evaluation would be correct, and the consequences of an incorrect assessment.

Hard-to-Find Information. Many participants knew exactly what information they wanted in order to evaluate a game, but there were no guarantees that information would exist in a form they could access or that they would be able to find (i.e., short of buying the game outright). Several participants cited the potential value of standardizing and compiling accessibility information in an easily discoverable place, such as a game's store page: *"You're putting out "minimum specs" for a game on PC; put out "minimum specs" on some scale of accessibility!"* (Eddy). A particularly difficult piece of information to find was a game's accessibility settings, which frustrated participants. This was a particular challenge for participants who relied on community-created content, as they shared that few gaming videos displayed the options menus in their videos, and when they did, it would be brief, incomplete, or difficult to find within the videos.

Uncertainty. Even in cases where participants could find the information they felt they needed, there was still looming uncertainty around whether their judgment would be correct. Almost all participants described instances where they expected a game to be accessible to them, yet encountered an unexpected barrier. Blue shared that, despite being very familiar with the Pokémon game franchise and having access to the list of settings in *Pokémon Sword & Shield*, they were confounded by a vaguely named setting: they expected "Disable Battle Animations" to stop the game's visually overwhelming camera movement in battle sequences, but it instead disabled a different non-problematic animation, leaving the game inaccessible to them.

Cost. Incorrect evaluations often had a financial cost: almost all participants had purchased games that they subsequently found were inaccessible to them, making Evaluation a riskier task.

In part due to the cost factor, Marc, Tristan and Avi all took advantage of *"unofficial"* means of playing games. Marc and Tristan both used free community-made emulators (i.e., software on a computer or smartphone that allows playing games from a particular console), which both minimized the cost of trying a new game and enabled playing community-made versions of a game that were more accessible (see Section 3.4.3). Avi found similar value in a local game store that sold discounted, pirated versions of games: *"There was a huge supply of pirated games for [about a dollar each]. It's still an affordability [issue]– but it's still better than paying full price for the game. Buying a [pirated] game and it not working was not really that much of a heavy price to pay."*

Design Takeaways

Participant discussion of their Evaluation strategies surfaced the following key insights that informed our Design Recommendations:

1. Peers and community-created content were again considered highly valuable resources, further informing our recommendations to **Spotlight and Develop Community Resources** and support **Social and Independent Access Solutions.**

2. Participants also expressed a lack of faith in the ability of external resources to make accessibility judgments on their behalf, due to a combination of their specific needs, game preferences, and desired gameplay experiences. This further emphasizes the importance of publicizing all of a game's **Opt-In Features & Customizability,** as well as how a game might support **Metagaming and Unconventional Play.**

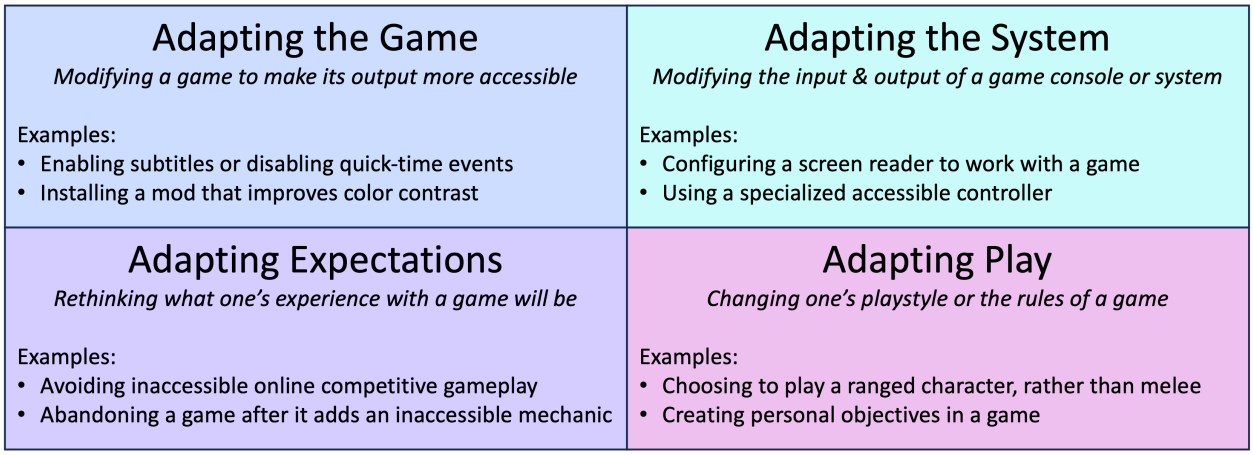


Figure 3.1: Overview of the four main strategies participants employed during Adaptation.

3.4.3 Game Adaptation

After discussing how games "pass" participant Evaluations, we moved into discussing the Adaptation Phase, in which participants got set up with their games and determined how they might modify aspects of their gameplay to make the experience more accessible. This phase also acted as a test of their Evaluations: in some cases, it was not until they started playing a game that participants found the game was not actually accessible to them.

Participants varied more in Adaptation than in the other phases. Participants described engaging in four different styles of Adaptation (previewed in Figure 3.1), which we call "Adapting the Game," "Adapting the System," "Adapting Expectations," and "Adapting Play." We also found that participants varied in their expectations for Adaptation, which we discuss in Section 3.4.3.

Adapting the Game

One class of strategy involved modifying the game to make its output more accessible. This often utilized existing features and settings, such as enabling subtitles or disabling elements like quick-time events. Although most of our participants had specific settings they searched for, many

commented on the ambiguous task of configuring settings in a game: *"It's totally an exploratory process with accessibility. In general, you often don't know what you need or what's available to you, right? At least for me, I kind of make it up as I go. [...] If there's a blurb that comes up, I'll read it, [check] what the name of the [setting] is, and then [try] it out."* (Aaron).

Difficulty levels were considered by many to be valuable for both accessibility and personalization. For Marc, *God of War: Ragnarok* was harder than expected due to an inaccessible menu that kept him from powering up his character, so he compensated by setting the difficulty option to an easier level. Unexpectedly, playing *Battlefield* on its hardest setting (i.e., "Hardcore Mode") with friends made the experience more accessible for Aaron than playing on its default setting: Hardcore Mode removed peripheral interface elements (e.g., current ammo and the map) that were already not visible to him, it thus equalized the playing field when competing against his nondisabled friends.

For some participants, mods (i.e., third-party software added to a game to add or change game elements) served as useful tools, such as by providing colorblind-friendly dual encodings for David or adding hotkeys to announce inaccessible on-screen content for Marc. However, Ken and Marc both noted there is a scarcity of mods related to accessibility, even in the mod-friendly game communities like *Minecraft*. Marc found most of his mods outside of 'official' channels, which created its own access issue: *"most of the mods, you have to download them and actually install them manually... put this file there and put this file here, so it's kind of a pain, especially for people who aren't good with computers."*

Adapting the System

Another strategy was to modify the input and output of a game system. In these cases, a game itself was left as-is, but the participant employed on specialized controller and assistive technology setups to play.

For some, this was a relatively simple process of configuring their regularly used assistive devices to work with the game (e.g., a screen reader, a hotkey mouse). System adaptations sometimes had the benefit of being reusable across games: Erich found he rarely needed to use in-game options, because *"I've adapted all my equipment, I don't need them [the games] to adapt again too much for me. [I adapted my equipment] just because I had to—because [the games] didn't do it before. I'm used to playing this way."* In other cases, each game required developing a specialized setup, producing a significant overhead when starting a new game. However, some participants took particular pride in the creativity of their setups: Marc celebrated the ingenuity of using optical character recognition to read out inaccessible on-screen text in *Animal Crossing*, and Eddy proudly shared the design of his custom 3D-printed wrist mount for his mouse. For Eddy, remapping his controls was also part of the affective experience of a game, leading him to fine-tune his mapping to create the ideal gameplay experience (e.g., increasing immersion in a racing game by mapping acceleration to a foot pedal).

Adapting Expectations

In some cases, participants did not expect to be able to reduce a barrier or find a workaround, so in lieu of changing the game, they changed their own expectations of what their experience with it would be as an inaccessible, unfixable object. Generally, these adjusted expectations left participants with two choices: to power through the inaccessibility, or to give up.

Choosing to power through an inaccessible portion of a game was described as a calculated risk: although the inaccessible portion would cause negative consequences (e.g., triggered symptoms, fatigue, frustration, discouragement), it was considered "worth it" to be able to engage with the other parts of the game. To some, powering through an accessibility obstacle was a satisfying challenge: Aaron enjoyed being able to beat his nondisabled friends in a competitive game where

he was playing at a disadvantage due to its inaccessibility, and Eddy enjoyed streaming games on Twitch where he could show off his ability to overcome access challenges to an audience. As he described it, *"It's something as simple as: how well have I been able to do something that someone else finds difficult that [isn't disabled]? If I'm here with my keyboard and mouse that are all adapted and no fingers, and I got into a 3-vs-1 firefight and won... people watching are entertained and encouraged by that kind of thing. [...] I'm playing for those kind of challenges."*

"Powering through" was not always an option: in some cases, there was simply no viable way to overcome a barrier. Caleb played a game which required wall jumping using a combination of inputs beyond the number of inputs he could simultaneously manage. In these and some other cases, the best option was simply to give up. If the consequences of engaging with a barrier were too steep or the expected enjoyment of the inaccessible game was too small, the decision to stop trying to make an inaccessible game accessible and move on to something else was considered a valuable part of the adaptation process. Although giving up on a game was never described positively, many participants spoke of needing to give up on some games as a frank reality of being a gamer with a disability. Eddy described abandoning *Gears of War* after an inaccessible boss battle, saying *"if it's too hard to beat within four or five times, I'll get bored, I'll just walk away. I'm not going to sit there and get frustrated because the video game is inaccessible and won't let me pass without hitting ten buttons."* Many participants did lament having spent money on a game they had to abandon, but some found ways to make the most of the situation. David, Marc, and Eddy would publish game accessibility reviews to provide feedback to developers and protect other disabled gamers from encountering the same issue.

Adapting Play

Many participants navigated accessibility barriers by modifying how they played a game, including selecting which activities they performed within the game world, redefining what their goals were, and even changing the rules of the game. The degree to which participants customized their playstyle varied significantly between participants, and sometimes varied for a single participant depending on the game and context.

Smaller customizations included choosing not to engage with a particular game mechanic, adopting a certain interaction style, or playing as a specific character. In an attempt to reduce triggering on-screen motion in the fantasy roleplaying game *Diablo II*, Blue described how they often chose to play as a character who could teleport, as an instantaneous teleport action reduced the duration of camera panning compared to when their character walked between points with the camera keeping the character centered on screen. Other participants like Ken and Marc described playing with ranged- or sniper-type weapons in games with combat to give them more time to react to enemy actions. In social or multiplayer contexts, the social nature of gameplay enabled other small customizations, such as allowing Aaron to avoid inaccessible navigation tasks by taking the co-pilot/gunner seat in *Call of Duty* vehicles or allowing Blue and Avi to opt out of additional inaccessible gameplay portions by having friends play them.

Other participants made much larger changes to their playstyles to adapt to a game, often oriented around creating entirely new objectives or sets of rules for gameplay. Both Dylan and Mira utilized games from the *Mario Kart* franchise as 'world exploration' games rather than as competitive racing games, in part because the racing was difficult and inaccessible to them and in part because they found the level design exciting and wanted to explore it further. Eddy discussed how he and friends used *Grand Theft Auto V* as a playground for live storytelling and roleplay (part of a popular phenomenon on Twitch known as 'GTA RP' [7]), which made the game more

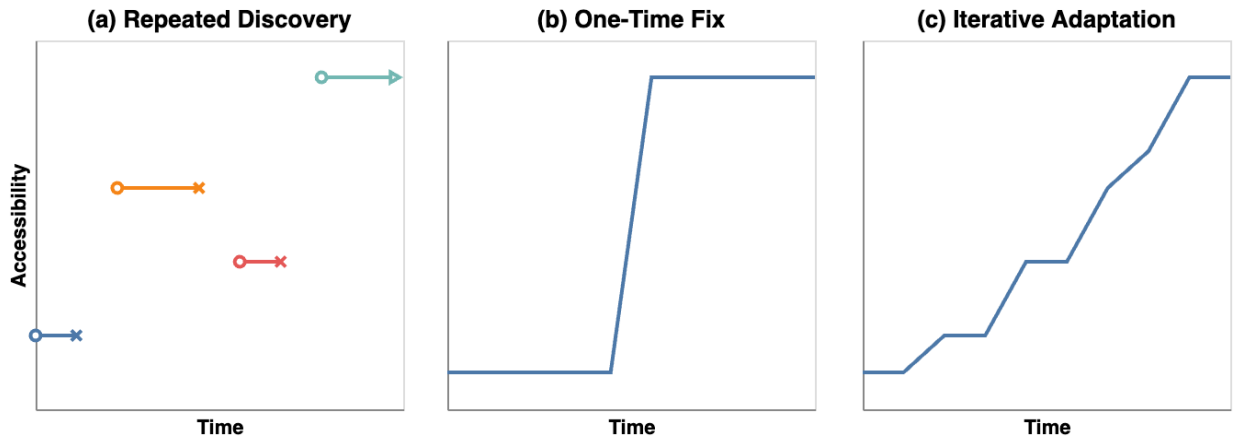


Figure 3.2: Sample timelines of participant adaptation behaviors. (a) A "Repeated Discovery" approach where a player tries many games looking for one that is sufficiently accessible to them from the start, abandoning games that are not. (b) A "One-Time Fix" approach where a player spends time developing a single primary adaptation to make the game accessible to them and relies on it for the duration of gameplay. (c) An "Iterative Adaptation" approach where a player progressively iterates on their adaptations or develops new adaptations throughout gameplay.

accessible to him than its "standard" playstyle.

In discussing this, many participants brought up the conflict between what they believed a game designer or developer 'intended' and what actually worked for them in interacting with the game. For one participant, playing a game in a way they felt was 'unintended' was interpreted as being bad at the game, but most participants celebrated creating a new game they felt was better suited to them: *"I don't really care what the game guy wanted. [...] He made his game. I'm going to decide how I'm going to play it and how I'm going to enjoy [it]"* (Erich).

These changes, both small-scale and large-scale, highlighted that flexibility and options are a particularly valuable attribute that made games more accessible. In contrast to games which force players down a specific path or only support one or a small handful of playstyles, games that were less constraining in what paths players were able to take through the game were more likely to be adaptable to an accessible state.

Extent & Duration of Adaptation

In discussing game adaptation with participants, we found that participants had widely different standards and expectations for the goal of this phase. All participants described expecting to engage in some amount of adaptation as they got set up with a game, as even the most accessible games generally needed to be integrated into a participant's overall system. However, the amount of adaptation varied, both in terms of how dramatically they changed the game and in how long they continued the process. Figure 3.2 shows sample timelines and progressions of three typical adaptation processes.

Repeated Discovery. For some, Adaptation was considered a last resort and avoided as much as possible (Figure 3.2(a)). For Kristina, needing to adapt a game indicated a failing in the Discovery or Evaluation phase that resulted in her playing a game that was not accessible to her from the start. When faced with an insufficiently accessible game, these participants described a preference for finding a new game to play rather than investing energy in developing workarounds.

One-Time Fix. For participants who used similar adaptation strategies across games (such as enabling specific game settings), Adaptation was often treated like an initial set-up process (Figure 3.2(b)). After this initial set-up, these participants expected to be able to play through the game without needing to modify things any further.

Iterative Adaptation. Other participants considered adaptation as an evolving, ongoing process throughout gameplay (Figure 3.2(c)). Rather than having a set list of options to check, Blue's adaptation process involved developing new gameplay strategies and testing mechanics to find a more accessible gameplay experience. For Ken, iteration took the form of regularly reassigning the hotkeys on his mouse as he identified which game actions needed to be performed more regularly than others. Rather than reaching a singular 'best' gameplay experience, this meant the gameplay experience could evolve and improve over time.

Design Takeaways

Participant insights around Adaptation ultimately informed all four of our Design Recommendations:

1. The Adaptation phase is where participants most actively leveraged flexibility in games, from leveraging built-in options to developing preferred playstyles and metagames. This informed our recommendations to offer **Opt-In Features and Customizability** and provide **Opportunities for Unconventional Play and Metagaming.**

2. Given the social nature of some participant metagames and playstyle-based changes, our recommendation to support **Social and Independent Access Solutions** is further reinforced. Some participant playstyle adaptations were also rooted in larger community practices (e.g., GTA RP), providing another reason to **Spotlight & Develop Community Resources.**

3.4.4 Additional Themes

In addition to identifying resources, strategies, and challenges specific to each phase, we identified two strategies participants leveraged throughout all stages of the game adoption process: (1) creating accessibility through social support, and (2) appropriating non-accessibility content for accessibility purposes.

Socially-Created Accessibility

All three phases of the game adoption process featured social accessibility solutions, from giving recommendations and advice to active involvement in co-creating access adaptations. Social interactions took a variety of forms, from playing with long-established groups of friends and

family to playing games online with strangers. Naturally, friend familiarity with a participant and their access needs affected how well they knew how to support their friend.

Game context also affected the social dynamic. When playing a competitive game against his brothers, Aaron did not expect them to go easy on him to try to make the game "more accessible" to him, saying *"and I don't want them to!"*. In some cases, friends supported access without reducing competition: Blue's friends would move their pieces for them in a virtual board game, and Ken's friends made sure to communicate accessibly on voice chat, even when playfully talking trash.

Across these social interactions, participants described the interpersonal bonding that occurred throughout the process of working together through access issues in games, which we can view as a form of Access Intimacy [109]. For Ken, the opportunity to talk with friends in online games was a valued experience, as voice channels were often inaccessible when playing in public lobbies with people who did not know how to communicate with him and had trouble understanding his speech. Dylan's mom noted a particular joy and affection that Dylan would express when his brother would help him through a challenge in a game. For Blue, it was particularly impactful when their friends and family would help them develop new adaptation strategies or adopt more accessible gameplay habits without being asked: *"it helps us feel connected... when somebody is able to help you hack a game, to make it work for you, it's really quite nice."*

However, social interaction around game adoption was not without friction. Mira and Blue both described how, given the specificity of their access needs, well-intentioned access judgments by friends were often incorrect: *"I'm probably just going to ignore it"* (Mira). This made the process of finding games more complicated due to newly added social pressure to try games they were confident would not work. Avi expressed that attempts to include him sometimes felt like *"an afterthought"*, creating an uncomfortable social dynamic where the game was not actually accessible to him but his friends did not feel they needed to do more to include him.

Design Takeaways. Overall, participants generally appreciated having trusted friends supporting

them and collaborating with them throughout the game adoption process. In some cases, friends enabled the process to be accessible in ways that would not otherwise be achievable. However, independently creating access was still core to all participant processes. This is the core of our recommendation to support **Social and Independent Access Solutions** in all stages of game adoption.

Appropriation for Access

Another cross-cutting strategy was content appropriation, wherein participants used media which was not explicitly accessibility-oriented for accessibility purposes.

Many participants cited YouTube gameplay videos and Twitch streams as valuable sources during Discovery and Evaluation, as they allowed seeing elements of the gameplay experience not captured in official sources like trailers or gameplay previews. However, with only a few exceptions, this content was not created with the explicit intention of providing this insight to gamers with disabilities. Participants instead appropriated this content as a free, easily discoverable source of information about game accessibility. Similarly, appropriation was a valuable tool in the Adaptation phase. In one case, Eddy utilized a specialized gaming mouse that recognized gestures related to the device's orientation and angle in 3D space. Although originally designed for flight mechanics in games like *Battlefield*, he co-opted this gesture support for use as a high-resolution input mechanism that did not necessitate a button press.

A notable aspect of appropriation in this context is the overwhelming degree to which participants relied on unintentional accessibility aids over intentional ones. Several participants noted that they did not even look for official accessibility resources from game developers, but instead turned to the sources that they knew would provide them with the relevant information (e.g., content creators on YouTube or Twitch). Some participants noted there was often a blurry distinction in whether a game feature was "intended" for accessibility. For Ken, the ability to 'ping'

locations in multiplayer games (i.e., an action that lets a player non-verbally highlight an in-game location to teammates) was a useful tool for rapid, accessible online communication, leaving him uncertain as to whether it was "technically" an accessibility feature. Difficulty levels, which are a hotly debated topic in gaming and game accessibility communities (e.g., [60, 149]), were brought up by most participants and commonly fell into this gray area. The general sentiment was that, regardless of whether they were designed with people with disabilities in mind, they improved the flexibility and accessibility of games.

Similarly, when it came to practices related to Adapting Play or creating metagames, mechanics that were leveraged usually had other purposes in the game. Many participants noted that games that allowed varying play styles often had at least one play style that was more accessible than others. This was the case in very open games that gave players freedom to choose what portions of the game to engage with (e.g., *The Legend of Zelda: Breath of the Wild*, *Minecraft*) as well as narrower games that provided a few specific choices, such as choosing between characters with different abilities and fighting styles (e.g., *Fortnite*, *Diablo II*).

Design Takeaways.

1. The expressed value of community-created content, whether accessibility-oriented or not, points to more ways game developers can **Spotlight and Develop Community Resources** to support accessibility.

2. Similarly, player appropriation of features that may not have been designed *for* accessibility further underlines the value of **Opt-In Features and Customizability** and providing **Opportunities for Unconventional Play and Metagaming.**

3.5 Discussion

3.5.1 Analysis: Comparison to Prior Work

Understanding Game Discovery and Evaluation for Gamers with Disabilities

Our results find that prior work in understanding how people discover games only partially characterizes practices of gamers with disabilities in Discovery and Evaluation. Prior work identified various metadata people seek out when finding and evaluating games, such as a game's subject, ratings, visual style, or relationships to other games [91]. We found participants utilized some of the same metadata, including genre information, visual style, and relational metadata (e.g., what studio produces a game, whether a game is part of a familiar franchise). The "four Rs" (i.e., reviews, ratings, rankings, and recommendations) [91] were selectively used and were primarily trusted when they came from sources participants knew considered accessibility (e.g., CanIPlayThat [151], friends who knew their access needs).

Participants also sought out metadata not explicitly documented by Lee et al., including what options and settings existed in a game and the degree to which they would be able to customize their gameplay experience. As previously discussed in Section 3.4.1, this metadata was often particularly difficult to find. Building off Lee et al.'s recommendations, we further encourage game publishers and distributors to compile and share this metadata to aid gamers with disabilities in their discovery and evaluation processes.

Consistent with prior work [91], we also found that multimedia and video resources were considered particularly valuable in the game discovery and evaluation process. Lee et al. highlighted the "concentrated" nature of video resources as beneficial for reducing the number of sources a person needs to consult in their process, and we found that this was additionally important to gamers with disabilities. Participants searched for more information and were able to consult

fewer resources (e.g., due to inaccessibility of resources, as with difficulty navigating the Steam store with a screen reader), so a single video could often constitute a majority of research players did for a particular game.

Hacking & Adapting Games for Accessibility

Consistent with Gonçalves et al. [53], Porter et al. [125], and Andrade et al. [5], we also found that social support was critical throughout all phases of the game adoption process. Participants cited friends and gaming communities as their most frequently used resources for navigating access issues. Within the space of adapting gameplay, we observed similar behaviors of copiloting [125, 53], the use of games as a jumping off point for social interaction [5], and segmentation of roles in play [125]. We also observed new social behaviors, including mutually agreed upon metagaming and collaborative development of accessibility adaptation, which further emphasize the importance of supporting socially-created access (see Section 3.5.5).

Our exploration of the adaptation phase also overlapped and extended prior work. In particular, our exploration of customization and personalized gameplay extends Gonçalves et al.'s concept of "playing your own game" [53]. However, we also identified adaptation strategies not previously discussed in literature, including 'adapting expectations' and 'adapting the system' in unique ways beyond the use of standard assistive technology.

3.5.2 Joy, Difficulty, and Disabled Gaming

Our results provide rich insight into how games produce experiences for gamers with disabilities that often differ from experiences of nondisabled players. However, rather than situating normative experiences of nondisabled players as the "goal" of accessibility for disabled gamers, we look to game studies literature around gameplay experiences to better understand what "accessibility"

might mean in gaming.

Access Difficulty

Salen & Zimmerman's widely used definition describes a game as "a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" [139]. Present in this definition is the concept of engaging with "artificial conflict" as fundamental to a game. Players seek out games, in some capacity, *to be challenged.* This fundamentally changes how we can consider accessibility in games. In most other domains, "accessibility" involves removing as much interaction challenge as possible. In games, however, removing all challenge produces an undesirable experience. Johnson describes this as the principle of "Friction that Fits": while most UI/UX domains strive to eliminate as much friction as possible, *"Great games don't remove friction; they have the best possible friction in the best places"* [83].

Scholars in game studies have defined different types of difficulty [78, 77] and demand [18, 20] to better classify how players can be challenged, producing concepts like 'emotional demand' (i.e., the demand of processing emotions a game invokes) and 'interpretive difficulty' (i.e., the challenge of figuring out what to do in a game). Following this practice, we introduce the concept of **access difficulty** in games: a specific type of challenge present in a game related to the task of navigating accessibility barriers.

Building on Hamilton's conceptualization of difficulty [60] and the social model of accessibility, we frame access difficulty as a product of the relationship *between a player and a game*, rather than something that can exist in a game in the abstract. Access difficulty is thus produced when a player ascribes challenge in a game as being the product of a mismatch between the player's set of abilities and their perception of the set of abilities for which the game was designed. Simply put, access difficulty is **inaccessibility understood through the lens of a game.**

Notably, a player does not need to identify as disabled to experience access difficulty: an

inexperienced gamer might experience access difficulty when playing a game like *Elden Ring* that is designed for seasoned players, or someone experiencing 'brain fog' might experience access difficulty when playing a puzzle game. However, disabled gamers can regularly encounter access difficulty when playing games not designed with their abilities in mind.

Consistent with other forms of difficulty and demand, access difficulty is a form of challenge that has the potential to produce satisfying gameplay experiences and may be actively sought out. This is consistent with some participant descriptions of navigating access challenges, such as Aaron celebrating beating his nondisabled friends in a competitive game while overcoming access difficulty that they did not need to navigate, or Blue's description of access intimacy in working with friends to develop new access strategies. However, not all challenge in a game is desirable, particularly in cases when the ability mismatch implicit in access difficulty leaves a player feeling excluded. As participants described, many challenges related to creating accessibility in games were considered tedious and frustrating, and these challenges produced barriers that prevented them from engaging with *desired* game challenges.

Disabled Gaming

Games research has explored the concept of *identity-based gaming,* the idea that facets of one's own identity influences how one views and plays a game. In particular, this model has been explored with marginalized populations in gaming, including black gamers [55, 56, 140], women gamers [59, 144], and queer gamers [137, 58, 57, 29].

Fundamental to the identity-based gaming framework is the acknowledgement that people have different goals in gameplay. This is true independent of identity (e.g., [154]), but further instantiated when one brings their identity to a game not explicitly designed with their identity in mind. For instance, Shaw found women gamers may reject "traditional" goals of identifying with game characters that do not represent them [144], while Gray found new goals emerge as

in-game objectives sometimes become secondary to social and community-building goals in black gamer communities [57, 58].

These goals, in turn, lead to differing gameplay behaviors, including identity reading (i.e., the practice of intentionally interpreting aspects of a game as reflective of one's identity [137]), intentionally "deviant" play (i.e., the practice of willfully violating expectations and social norms in play [55]), and queergaming (i.e., the practice of 'queering' games through creation of new playstyles that prioritize non-normative values [29]). Notably, this is most often an intentional, desired deviation from normative play that center's one's identity. These gamers *could* play the "normal" way, but choose not to as they often prefer their alternative gameplay style more.

With this framing in mind, we propose that gamers with disabilities similarly have alternative approaches and priorities in games, which we term **"disabled gaming".**

Disabled gaming can be characterized in part by player engagement with access difficulty. Disabled gamers bring a degree of expertise to the challenges posed by access difficulty, in part due to being more frequently confronted with access difficulty than nondisabled players (as well as experience navigating access challenges outside games). However, as access difficulty is not solely experienced by gamers with disabilities, disabled gaming is characterized in part by *how* players navigate access difficulty, alongside how frequently they engage with it.

Disabled gaming involves more than just navigating access difficulty: many participants also described participating in forms of deviant play, sometimes prompted by specific access barriers, and other times simply due to having differing priorities from those "expected" by the game. Participants' custom games and unique gameplay styles (see Section 3.4.3) often constituted deviant forms of play or 'metagaming' [16], and cases where they changed their gameplay expectations (Section 3.4.3) denoted specific instances of changing their gameplay behaviors from established norms. In some sense, even the act of developing access adaptations can be considered a form of deviant metagaming: participants celebrated their own ability to devise new solutions, as if

playing a puzzle game built on top of the existing game.

Designing for Disabled Gaming

Similar to how Ruberg describes queer gamers reading their identity in non-queer games [137], we can understand that processes of hacking, adapting, and reinterpreting games are similar forms of identity reading. Even when games are not necessarily designed with the intent of presenting these challenges to gamers with disabilities, gamers with disabilities can find these challenges and engage with them to create new modes of interacting with the games. Inaccessible games unintentionally create opportunities for access intimacy, "hard mode" challenges to overcome, and adaptation "puzzles" that let players derive satisfaction from their creative solutions. The social nature of many participant approaches to Discovery, Evaluation and Adaptation also reflects the emergent community and shared experiences gamers with disabilities have navigating this space.

However, this is not to say that accessibility barriers are acceptable and do not need to be addressed. Instead, it is a testament to the richness of disabled gaming experience that should not be viewed as something to unilaterally "fix". For example, we can hypothesize how this instinct might manifest in potential "solutions" to access barriers in games. In the racing game *Mario Kart*, an access "solution" could be a "driving assistant" that ensures the player stays on the road, to help support players for whom the mechanical difficulty of controlling the vehicle is an unsatisfying access challenge. However, this would completely inhibit Dylan and Mira's open-world exploration metagame, prevent Aaron from being able to celebrate a "hard mode" victory, and inhibit Blue's access intimacy in developing workarounds with friends. Although few would argue that a driving assistant makes the game *less* accessible, it fundamentally changes the experience of playing and blocks disabled gamers from being able to engage in unconventional, disabled gaming.

Conversely, we can also see how designing for disabled gaming discourages "siloed" accessibility

solutions, such as designing games that are specifically targeted at a disabled audience (i.e., a contrast to making games with a larger audience accessible for disabled players). Disabled gaming is rooted in finding one's own unique mode of play in a larger set of options, and it is further augmented in how individual unique modes of play interact with each other. Although genres like audiogames and single-button games still have their own merits, they are not a substitute for supporting disabled gamers in larger mixed-ability contexts.

In disabled gaming, player preferences can vary dramatically around what challenges are "satisfying": difficulty posed by an access barrier can be satisfying to one player, frustrating to another, and utterly game-breaking to a third. There is no one solution that will improve every player's gameplay experience. This points to the importance of options and customizability in disabled gaming: game designers should prioritize giving gamers the ability to select what challenges they wish to engage with while providing options to circumvent the challenges they do not.

3.5.3 Games & Consequence-Based Accessibility

Our exploration of 'adapting expectations' points to an opportunity to better understand video game accessibility (and accessible recreation at large) through the lens of consequence-based accessibility [100]. Consequence-based accessibility frames an interaction not as a binary 'accessible' or 'inaccessible', but as a personal calculation of the expected benefit (e.g., enjoyment, benefits to one's health) relative to potential consequences (e.g., aggravated symptoms, social discomfort). With this framework, we can better characterize judgments participants made during Evaluation about whether an inaccessible game was "worth trying", as well as whether and how to adapt a game to better meet one's access needs.

Navigating an access barrier was sometimes a high-risk situation for participants (i.e., an action with a large potential consequence). For participants whose disabilities could be triggered or exacerbated (e.g., those with chronic health conditions or who experienced physical pain when navigating barriers), there was a relatively stringent threshold during Evaluation: a 'false positive' accessibility judgment (i.e., an inaccessible game being deemed accessible) had much more severe consequences than a 'false negative'.

Consequence-based accessibility also can characterize participant choices about how, if at all, to adapt games with accessibility barriers. Some participants who employed the 'Iterative Adaptation' approach (Figure 3.2(c)) described deriving joy from developing adaptations or progressively increasing skill in an inaccessible game. In these cases, we might conclude the 'consequence' of needing to develop an adaptation was less severe than the anticipated 'benefit' of the adaptation (or that the chance to develop an adaptation was a 'benefit' in itself), making continuous adaptation a worthwhile endeavor. On the other hand, for participants engaging in 'Repeated Discovery' (Figure 3.2(a)), the task of developing and implementing adaptations was considered overwhelmingly burdensome, and their calculation often led them to abandon a game if it was initially too inaccessible. It also bears noting that some participants reported using multiple of these adaptation behaviors in different situations, further emphasizing the importance of context in characterizing how and why gamers with disabilities might choose to adapt games.

This preliminary analysis points to the complexity underlying decisions by gamers with disabilities to engage with games, as many factors seem to underlie participant judgments around a game's accessibility and value. We encourage researchers to further investigate these considerations, and highlight the opportunity to use CBA as a tool for exploring accessibility considerations in games and recreation.

3.5.4 Shortcomings of Current "Official" Solutions

In recent years, game platforms and developers have worked to improve the visibility of game accessibility features. For example, Xbox's Accessibility Feature Tags [164] provide valuable details in the Xbox Store about game accessibility features, and studios like Naughty Dog have actively marketed cutting-edge accessibility features of their games [48] However, despite these features and assurances, very few participants cited using "official" resources to find and evaluate games. This begs the question: What are the shortcomings of the existing solutions, and how can they be made more useful for gamers with disabilities?

Lack of Resource Visibility

One key takeaway from our study was a general lack of awareness of the existence of existing resources. Historically, there has not been much "official" support for accessibility in games, and participants confirmed they do not expect to find official resources due to their established impressions of game companies. Thus, despite these recent improvements, it seems many gamers with disabilities may not currently be in the practice of seeking out these resources. As a potential solution to this issue, participants proposed to make these resources more "in your face" and easier to unintentionally stumble upon, such as by listing accessibility features alongside other core information that is commonly looked up (e.g., device requirements on a PC game's store page). For games companies that have already invested in developing new accessibility resources, working to make their resources more easily discoverable might be a high-impact step towards more widespread accessibility.

Unreliable Judgments

Another issue highlighted was a general uncertainty regarding the accuracy of existing accessibility judgments provided by game companies. In some cases, this was attributed to a lack of context around what tools and solutions a participant was using that would change what features of a game pose barriers to them. For example, many of the more experienced participants have established their own workarounds for certain barriers (see Section 3.4.3) that might complicate a simple, binary judgment of "this game is (in)accessible to people with [some disability]". Even information around low-level input requirements of games, such as "requires holding down buttons," might not be sufficient in cases where context for an input affects what workarounds a player might be able to utilize.

In other cases, the participants, as experts in their own disabilities, felt their understanding of their own disability was not commonly or accurately reflected in resources attempting to aid in accessibility judgments. We can also look to Mack and McDonnell et al.'s work on the misrepresentation of people with chronic illness in existing models of disability [100] as further evidence that binary judgments about a game's accessibility might not be considered reliable or trustworthy by players. This issue might address some of the remaining uncertainty around why gamers with disabilities do not currently use official resources. Ultimately, many of these resources attempt to make judgments on an individual's behalf, rather than equipping them with the resources needed to make these judgments for themselves.

3.5.5 Design Recommendations

Based on our findings, we present four main guidelines for game developers and distributors to better support gamers with disabilities in the game adoption process.

Spotlighting & Developing Community Resources.

As we observed in our study, many gamers with disabilities rely on community-created resources (e.g., Twitch streams, YouTube Let's Play videos, blogs) for informing their discovery, evaluation, and adaptation processes. However, searching for resources that contained all the information they needed sometimes proved challenging, and obtaining desired information often required cross-referencing multiple sources.

Game Distributors. Based on this, game distributors should consider providing a centralized resource that compiles information from these various community-created sources, including text, images, and video information that gamers with disabilities can utilize to more easily retrieve the information they need. Of course, game distributors should also be careful not to exploit community-created content as a form of accessibility consideration without crediting and compensating the creators appropriately.

Game Developers. Additionally, several of our participants who stream on Twitch noted that they occasionally get sponsored by developers and distributors to play a particular game on their stream. With this infrastructure already in place, distributors can consider how they might better collaborate with streamers to spotlight a game's accessibility features, producing easily discoverable community resources with high-quality information on these features. Alternatively, given that game developers have access to the complete game prior to its release, they also have the ability to create gameplay videos that demonstrate the complete range of game elements players will encounter within the game.

Streamers & Content Creators. Furthermore, this points to a way that streamers and other gaming content creators can further support gamers with disabilities who are already in their communities. Although participants shared that they know what to look for as they search through this content, there is also an opportunity for content creators to explicitly highlight

relevant accessibility information in an easily discoverable manner, such as by displaying the game's accessibility menu at the start of a gameplay video.

Opt-in Features & Customizability.

A primary takeaway from our study and analysis is the importance of customizability in the gameplay experience for accessibility. Different players have different needs and preferences, and there will never be one "universal" game experience that works for everyone. Based on this, a core principle that should be put forward in design is the idea of opt-in game features. There are various granularities where this can be implemented: at an input level (e.g., opting into button holds or motion controls), a mechanics level (e.g., opting into quick-time events), a thematic level (e.g., opting into gory content or jump-scares), or even a higher organizational level (e.g., opting into a stage or level of a game).

Game Developers & Designers. This can be integrated with the existing idea of game curation and balancing: game developers and designers can still curate a default or "recommended" game experience, but the added flexibility of allowing players to specify what challenges and tasks they want to engage with can make games significantly more approachable to people with diverse needs and preferences. For players who know what they want, having options will always make a game more accessible to them.

Game Distributors. Furthermore, participants explicitly expressed a desire for game distributors to surface what options exist in games, extending traditional store page sections (e.g., on hardware requirements, supported languages). When providing this information, distributors can also provide concrete examples of what is affected by different options, as option names were sometimes ambiguous or misleading. Notably, this is *not* a request to attempt to make judgments around who a game is accessible to, as participants expressed that that is a highly personal decision. Instead,

this is a call to consolidate and publicize information that can inform player decisions.

Social and Independent Access Solutions.

As described in Section 3.4.4, social accessibility is a major component of existing practices of gamers with disabilities and a valuable part of the disabled gaming experience.

Game Developers & Designers. Based on this, we would encourage developers and designers to consider how they might more directly design for social forms of accessibility support within their games. This could be achieved in a variety of ways, including adding more split-role co-op features (e.g., as with the co-op crew mechanic of *Sea of Thieves* that let Marc steer his group's ship) or adding support for custom challenges in competitive games (e.g., inspired by Aaron's use of *Battlefield*'s limited HUD in Hardcore Mode that leveled the playing field with nondisabled friends).

Notably, it is important to ensure a game can still be accessible *without* the support of others. But in gaming contexts that are already inherently social, enabling friends and allies to support the creation of accessible gameplay experiences presents a major opportunity for improving the quality of game accessibility.

Player Communities. Participants primarily described making adjustments to gameplay when they were playing with friends who already knew their access needs, but there are certainly opportunities for well-intentioned player communities to more readily support gamers with disabilities in creating accessible experiences. Similar to how game developers might implement flexible game features, players might consider how to develop flexible gaming behaviors that can adjust to access needs of co-players. This could manifest in countless ways, like being willing to take the driver's seat in a *Call of Duty* vehicle or adjusting communication practices in an online voice chat. At a high level, normalizing communication around player access needs and

willingness to collaboratively implement access hacks could go a long way to enabling gamers with disabilities to socially implement access in multiplayer games.

Opportunities for Unconventional Play & Metagaming.

As seen throughout our research, gamers with disabilities often play games in "unconventional" ways that are not necessarily what the designers and developers intended. This is a core part of the disabled gaming experience, and a key tool for hacking access in inaccessible games.

Game Designers & Developers. With this in mind, we recommend that game designers keep opportunities open for these forms of play, rather than railroading players into an "intended" play style. To take this a step further, designers may even consider alternative play styles and metagames throughout the design and development process, and might explicitly create and highlight opportunities for these diverse play styles within their games.

Streamers & Player Communities. Learning from how *GTA RP* gained popularity in a wider community and was then appropriated by gamers with disabilities, gamers might consider accessibility benefits when developing their own new metagames and playstyles, especially if participating in larger social trends. Although an "accessible metagame" can vary greatly game to game, playstyles that increase flexibility beyond the typical expectation are a good place to start. Additionally, normalizing gameplay variants and informal "house rules" in multiplayer games can support gamers with disabilities who utilize unconventional playstyles for access. For example, a 'melee only' round of an FPS game may not be the traditional way to play, but a player might propose it because aiming weapons is inaccessible to them. For players that can play accessibly in either mode, agreeing to change the rules can be a strong act of allyship and collaborative access creation.

3.6 Coda: The Game of Accessibility

In resolving discussion of this project, it is worthwhile to bring this back to our ongoing discussion of the Game of Accessibility. A core contribution of this was our development and exploration of the three-stage framing of accessible game adoption, which we have subsequently expanded in our exploration of AT adoption (see Chapter 5). A major implication of this framing is how it clearly defines points where a person's objectives change throughout the adoption process, which can help us understand how player objectives change throughout the Game of Accessibility.

In identifying strategies and challenges in each phase, we can also begin to model parts of the Game and understand how much the Game itself also varies over time and contexts.

Another major contribution of this work was our exploration of access difficulty, and specifically this articulation that sometimes inaccessibility (or specific *types* of inaccessibility) in games was not viewed as universally negative.

This also emphasizes how that not all PWD employ the same value calculations when navigating access barriers– even independent of high-level strategies, there are different factors clearly being optimized for throughout each individual's gameplay experience. This particular insight would go on to inform and motivate portions of our work on Modeling Accessibility, discussed in the following chapter.

Chapter 4

Modeling Accessibility: Characterizing What We Mean by "Accessible"

After exploring the topic of technology adoption within a gaming context, I now broaden my research scope to explore everyday interactions with technology.

In light of the insights around the many different ways disabled gamers might choose to navigate an access barrier and the contextual factors that influence that decision, a team of collaborators and I came together to further explore the nuances of how creating access actually happens in practice. Another major contemporary work in the space was Mack & McDonnell et al.'s *Chronically Under-Addressed: Considerations for HCI Accessibility Practice with Chronically Ill People* [100], which also complicated the definition of 'accessibility' through their **consequence-based accessibility** framework. To combine efforts, our final team consisted of of authors from *Hard Mode* and *Chronically Under-Addressed*, as well as several other collaborators.

The project overall was a highly collaborative effort, with the four more junior authors (myself, Kelly Avery Mack, Emma J. McDonnell, and Aaleyah Lewis) all contributing to all portions of the work. In particular, my contributions were primarily in overall conceptual framing, qualitative

analysis, theoretical development of our accessibility modeling framework, and the synthesis of design recommendations.

A version of this work was published at ASSETS 2025 as *Modeling Accessibility: Characterizing What We Mean by "Accessible"* [101]. For the purposes of this dissertation, I have restructured and reframed portions of this work to be in closer conversation with my thesis topic. In particular, the Introduction (Section 4.1) and Background & Related Work (Section 4.2) have been reworked, while Methods (Section 4.3), Results (Section 4.4), and Modeling Accessibility (Section 4.5) are largely unchanged. Additionally, I close this chapter with another "coda" bringing this project's findings into more direct conversation with our discussion of the "Game of Accessibility".

4.1 Introduction

As accessibility research and the development of access technologies progress, there is an ever-growing number of ways to navigate accessibility barriers. Previously insurmountable access barriers can now be plausibly bypassed; and clunky, imperfect access solutions have been improved over time and evolved to address a changing technology landscape.

Now, with a growing number of options, even simple access barriers might have multiple "solutions", leaving PWD with the double-edged sword of having options to evaluate and choose between. For instance, consider a situation where a paraplegic person who uses an electric wheelchair needs to attend an event a couple blocks from their home on a rainy day. Their wheelchair might get damaged if it gets wet, so they consider multiple options: they could call for a wheelchair-accessible car service; they could use a different mobility device, like a manual wheelchair; they could try to attend the event remotely on Zoom; they could try to cover parts of their wheelchair to shield it from the rain; and so on.

However, each of these options has its own trade-off: the car service might be expensive and

take a long time; the manual wheelchair requires additional physical exertion (and even having a manual chair they can easily switch to); attending the event remotely might not be an option, and can dramatically affect their experience at the event; and attempting to shield the electric wheelchair risks damage to a very expensive piece of equipment. Depending on the person, the circumstances, how important the event is, and what the person most values in this setting, they might choose to navigate the situation in any number of ways.

Now consider that a disabled person might make dozens of these decisions each day, making different choices in different instances. And further, different people might make completely different choices in the same scenario. Ultimately, it would seem there is not necessarily a single "best" way to navigate a particular access barrier– PWD all have their own approaches, preferences, and strategies in how they navigate access barriers, complicating our understanding of how best to provision accessibility. This of course becomes a critical consideration for AT designers: *how can we create the right tools if we lack a model of how tools are considered and applied?*

Many of our current models of accessibility still use a more "binary" representation of access: a situation is either accessible or inaccessible. However, some newer models have sought to add further complexity to our definition of accessibility. For instance, Mack & McDonnell et al.'s model of *Consequence-Based Accessibility* [100] describes how, particularly for people with chronic illnesses, a task that is technically completable may later incur consequences that are too steep to justify performing the task in the first place– in effect, the ability to complete a task is not sufficient to determine if the task is actually accessible.

Bennet et al.'s model of *interdependence in accessibility* [8], which leverages longstanding principles of interdependence from disability justice (e.g., [74]), teases apart the difference between ways to provision access that are doable vs. those that are actually *desired*. For instance, using technology to independently navigate a barrier may not actually be preferred over asking another person for support.

Other models seek to inform the process of designing technology that considers disability, such as universal design [95, 124, 41], inclusive design [32] and ability-based design [161].

However, with so many types of accessibility and access considerations, we have a new problem: there are so many different ways we might model how PWD actually provision access in their lives, what their specific goals are, and how they navigate various access barriers, leaving us no closer to our goal of knowing how to best support PWD through AT design.

In this work, we argue that a clear conceptual understanding of accessibility is necessary to grow the field. Just as critical disability studies scholarship has progressed in response to models of disability [113, 143, 114], a concrete understanding of *how to model accessibility* can provide designers and researchers insight into how technology operates within the context of disabled people's lives. Our analysis of participant experiences characterizes the range of meanings, goals, and experiences currently combined under the umbrella of 'accessibility.' In doing so we aim to expand the domains of access that we study and increase the relevance of our work to people with a diversity of disability experiences.

We are guided by the following research questions:

1. What is the range and variation of ways technology facilitates access?

2. How do an individual's identities and context impact what it means for technology to make something accessible?

To answer these questions, we conducted hour-long, semi-structured interviews with 25 people who use technology to make their world more accessible. Our findings identify three key dynamics around how technology improves access in the lives of participants.

First, we identify that access barriers can take many forms. We name four major types of access barriers we observed in our data: failure point (i.e., a task cannot be completed), usability (i.e., any existing approaches to a task are unsatisfactory), bodymind (i.e., existing approaches to

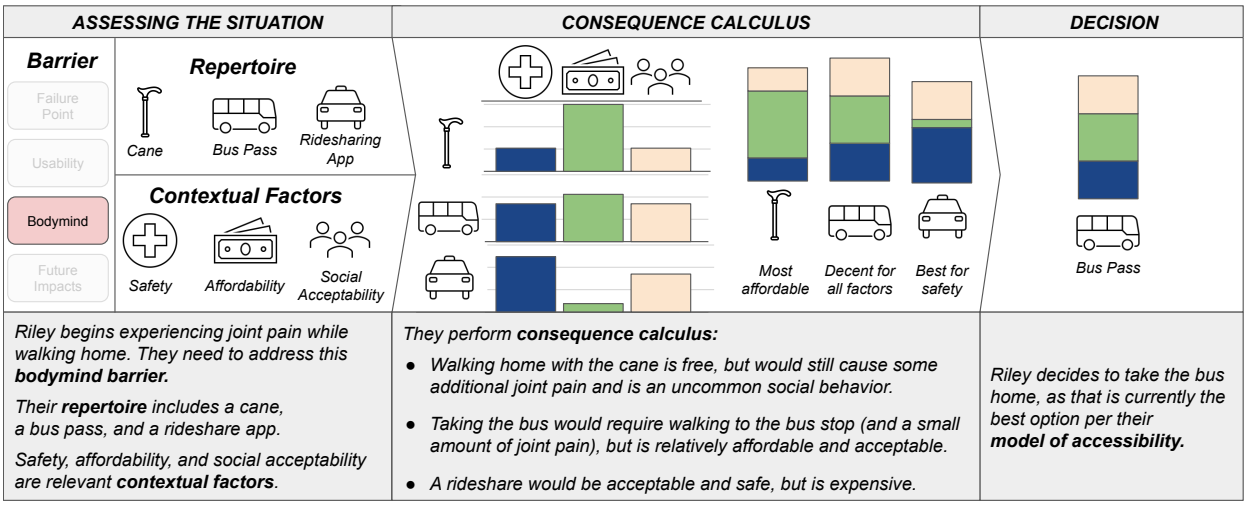


Figure 4.1: An illustration of the process of modeling accessibility

a task lead to an undesirable experience for an individual's bodymind), and future impact (i.e., while a task may be doable in the moment, it will have a negative future impact).

Next, we found that participants used a range of tools in concert to create access. We highlight the importance of considering those tools as a *repertoire* and identify how tools interact: working in *combination* to make a task accessible and serving as multiple *options* to accomplish a single task.

Finally, we highlight the ways that contextual factors in an individual's life–identities they hold, communities they belong to, properties of their technologies, and situational considerations—shape access. These factors inform the available options for an individual's repertoire and the experience of using technology for access.

From these findings, we create a process for *modeling accessibility*, articulating the nature of access barriers and the process of moving toward access. Our modeling first characterizes a moment of inaccess, highlighting three pieces of information that are central to someone's

experience: relevant contextual factors, the access barrier, and the available tools in their repertoire. Further, it describes a person's process of deciding how to move toward access by performing *consequence calculus* [99]—outlining possible options to address a specific type of access barrier, weighted based on contextual factors and options afforded by a person's repertoire. We conclude with implications for accessibility researchers and designers, including how this process can be used in research and design and other considerations for modeling accessibility.

In summary, this work contributes:

1. A characterization of accessibility as fluid and dependent on the type of barrier an individual faces, the tools in their repertoire, and contextual factors

2. A process for modeling accessibility, combining our characterization of accessibility with consequence calculus

3. Implications for design that enable researchers and practitioners to understand and design for accessibility as a complex and situated process, better reflecting disabled people's lived experiences

4.2 Background & Related Work

Accessibility researchers do not necessarily have a shared definition of what makes something "accessible", either theoretically or empirically. Accessibility research has engaged with (and borrowed from) design paradigms from other fields to help motivate increased access (e.g., universal design [95], inclusive design [32]) and developed guiding paradigms for specific kinds of accessible technology design (e.g., ability-based design [161], interdependence [8]). United in aims to increase accessibility, these disparate approaches range in philosophy and execution–perhaps one design should work for everyone [95]; or maybe universal access actually manifests through

customization capabilities [161]; or, crucially for this work, the path to access may vary, but people with disabilities should be central to how access is defined and enacted [8]. As the field develops more approaches to accessible design practice, what accessibility *is*, at its core, remains under-discussed.

Moreover, recent work has shown that accessibility research has been serving only a subset of people with disabilities, necessarily leading to a limited understanding of access. In a survey of accessibility research from 1994-2019, Mack et al. [97] identified an overrepresentation of research into some types of disabilities (e.g., vision disabilities) and an underrepresentation of others (e.g., chronic illness, intellectual and developmental disabilities). Recent work has outlined approaches to better include disability groups such as adults with ADHD [148], people with psychosocial disabilities [131], and chronically ill people [99] in accessibility research.

Similarly, accessibility research has evolved to include broader models of what is affected by inaccessibility, such as expanding to consider "bodymind". Bodymind is a concept introduced by Margaret Price and quickly adopted by many disability scholars and activists [126]. As defined by Sins Invalid, it refers to "the relationship between the human body and mind as a single integrated entity... to affirm the reality that our minds and bodies cannot be separated" [74].

Additionally, recent work has called out a lack of attention to how identities such as race [97, 63, 35, 9], gender [9], and queerness [35, 9] impact disabled people's experience using accessible technologies. Any understanding of access will not be complete if it is not intersectional, and we center diversity across many axes in our theorizing about access.

Within this work, we approach our goal of modeling accessibility in a way that considers these highly varied versions of accessibility, but we do not aim to fully supplant these models and frameworks. Instead, we aim to introduce a model that can be used in tandem with these models to explain how the practice of creating access can manifest in these many different ways.

4.3 Methods

We conducted 60-minute semi-structured interviews on Zoom with 25 participants to understand 1) how people use tools in the process of making their world more accessible, and 2) key factors that shape accessibility.

4.3.1 Protocol

Prior to the study session, we coordinated with participants to ensure we could meet their access needs. We provided a range of accommodations—most commonly, we sent interview questions in advance, used Zoom's automatic captions, and took breaks throughout the session. Two members of the research team attended each interview, with five authors in total conducting interviews. This study was reviewed and deemed exempt by the University of Washington's institutional review board, and all participants were given a $50 Tango gift card for their time. We asked participants for their consent to record interviews – all but one participant consented to the recording and we instead documented that interview with copious notes.

Interviews focused mainly on 1) how the tools participants use for accessibility operate in their day-to-day lives, and 2) how the non-disability identities they hold and communities they belong to shape how they engage with technology. We began interviews by providing participants a sense of what tools were in-scope for our session, which includes tools traditionally understood as assistive but also technologies that provide access despite not being explicitly designed to do so. We then asked participants about their disability identities and the assistive tools they used. Next, we focused on understanding how their tools functioned in their daily lives and how they came to adopt those tools. Finally, we asked participants to reflect on how identities they hold or communities they belong to interact with their experience of accessibility and use of tools. We encouraged participants to consider identities linked to demographics, like race, gender, or

preferred language, as well as identities that stem from other relationships or passions, like being a parent or a dancer. Interviews were semi-structured and tailored to each participant.

4.3.2 Participants

We recruited participants through US-based and local community organizations that serve people with disabilities, some which specifically focused on one category of disability (e.g., people with vision disabilities) and some which included people with disabilities generally. We also utilized snowball sampling and our personal networks to round out our sample. We recruited people who identified as "disabled," or as having a related condition or identity that results in accessibility needs in daily life including having a chronic or mental health condition or being neurodivergent. In the screener survey, we also asked participants to optionally share their race, gender, age, and any other facets of their identity they felt impacted their perspective on assistive technology. We selected participants from the pool of those interested by maximizing for variety among disability and other reported identities. In total, we recruited 25 participants. While many participants identified as being neurodivergent or having a chronic or mental health condition, most also held additional disability identities. Participant demographics are summarized in Table 4.1.

4.3.3 Analysis

Four authors then analyzed automatically generated interview transcripts. All interviews were coded using both the audio recording and transcripts, and all quotes included in the final work were checked against original audio recordings to ensure accuracy. To begin the coding process, authors reviewed a subset of transcripts, reading for high level themes. We converged on eight themes including "assistive technology use case," and "identity impacting tool use." Then, we sorted each transcript into these eight themes. Each transcript was reviewed by two authors, one

Table 4.1: Participant demographic data. All fields were open response text boxes where participants could write their answer. Researchers grouped responses into those shown in the table, drawing from exact participant language as much as possible.

Disability	
Addiction	2
Blind or Visually Impaired	5
Chronic Illness	9
d/Deaf or Hard-of-Hearing	5
"Disabled" Generally	5
Intellectual or Developmental Disability	3
Mental Health Condition	7
Motor Disability	9
Multiple Disabilities	14
Neurodivergent	11

Race	
African American or Black	3
Afro-Latine	1
Asian/Asian American	5
Mexican, Latin American, or Latinx	3
Multiracial	4
Person of Color	1
South or Southeast Asian	2
White	12

Age	
18-25	4
26-35	9
36-45	4
46-55	4
56-65	1
66-75	2

Gender	
Female/Woman	11
Genderqueer	2
Gender Non-conforming	1
Male/Man	6
Nonbinary	5
Trans Woman	1

conducting an initial sorting pass with the second checking their work. After this stage, authors narrowed the focus of our analysis to six main themes that were most relevant to our work's evolving focus.

We then conducted deeper inductive or deductive coding pass on the remaining six themes. For themes where we needed to extract a list of information (e.g., types of tools used), we performed deductive analysis. For themes that we needed to analyze more deeply (e.g., identity impacting tool use) one author affinity diagrammed the data, and their work was double checked by another author. Affinity diagrams were presented to the four coding authors for review and discussion. Our results come from a synthesis of our deductive and inductive analyses.

4.3.4 Positionality

The findings in this work are indelibly shaped by authors' identities and perspectives. Many authors involved in this project are disabled, and our analysis is grounded in that lived experience. Our team of authors include individuals who identify as Black American, Latinx, and White American, and are all based in the United States. Authors have disciplinary backgrounds in computing, design, and disability studies and hold significant expertise in accessibility research. We acknowledge that our understanding of disability, accessibility, race, and other identities is rooted in a U.S. context, based on our collective positionality and experiences.

4.4 Results

Our findings highlight how access technologies function in participants' lives, and the factors that impact their use. We first provide an overview of technologies participants used and identities that shaped their experiences of accessibility. We then identify four major types of accessibility barriers participants faced: failure point, usability, bodymind, and future impact barriers. Next, we discuss how participants described their intertwined use of, sometimes extensive, collections of assistive technologies throughout their lives, which we term *repertoires*. We conclude by highlighting contextual factors that impacted technology acquisition, selection, and use, emphasizing that a participant's identities greatly impacted if or how well they could use a tool.

4.4.1 Disability and Technology Background

To begin, we highlight the variety that characterized participant experiences with disability, tool use, and non-disability identities.

Participants in our study held a wide range of disability identities, which led to a diverse

Table 4.2: Notable tools used by 8 participants, selected to highlight diversity in disability identity and tool use. To preserve anonymity and decouple this more specific and potentially identifying data, we refer to these using row numbers (i.e., rather than participant identifiers).

Row #	Disability Type	Notable AT
R1	Neurodivergence	Podcasts, Fidget Toys, Headphones, Computer Games, iPad
R2	Motor, Chronic Illness, Neurodivergence	Wheelchair, AAC, Eye Gaze Detection, Adaptive Gaming Console
R3	Motor, Chronic Illness	Grocery Ordering Service, Portable Ramps, Grit Freedom Chair Outdoor Active Wheelchair, Dressing Stick, Smart Home Devices
R4	Motor, Chronic Illness, Mental Health, Neurodivergence	Antidepressants, Adderall, Captions, Elevated Second Monitor, Earplugs
R5	d/Deaf/Hard of Hearing, Motor, Chronic Illness, Mental Health, Neurodivergence	Brace, Lyft, Translation Apps, Video Remote Interpreting, Microsoft Teams
R6	Vision Disabilities	Audible Pedestrian Signal, Aira, Braille Display, Crosswalk Tactile Bump Mats, Guide Dog, Seeing AI, Headphones
R7	Vision Disabilities, Motor, Intellectual/Developmental, Neurodivergence	AAC, Dragon Dictation Software, Yoga Mat, Screen Reader, Adaptive Cooking Utensils
R8	d/Deaf/Hard of Hearing, Chronic Illness, Mental Health, Neurodivergence	Non-Western Medicines, Ancestral Herbs, Google Translate, Wiktionary, Transcription

Table 4.3: Instances demonstrating how identity factors related to demographics, community, and activities impact AT use.

Identity Category	**Identity Factor**	**Example Participant Quote**
Demographics	Age	*"When you think of hearing aids and pacemakers ... the typical demographic that uses them is much, much older ... When I was 12 years old getting hearing aids sucked. I hated the idea of it ... There was that sense, 'this is gonna be really othering or really alienating."'* - P2
	Class	*"My class background affect[ed] my use of technology ... I grew up with parents who were both very highly educated, in a traditional sense, and also worked as engineers in Silicon Valley. So we always had computers growing up. So I would say in an indirect way, that's also led to me being very comfortable using [the] Internet and computer to look for resources."* - P8
	Ethnicity	*"My parents' own history of poverty, and their mentality around money has also, and I think, to some extent, it might be kind of a common experience among Chinese immigrants or Asian immigrants, even if they have money, behave as though they're still living in scarcity. So, there's this component where maybe I could afford, for instance, to buy some software. But I wouldn't do it, because it's something that I was not raised to think that was necessary."* - P8
	Gender	*"I do change my gender presentation based on how anemic I am because I have historically received more street harassment when I dress more butch and so I tend to dress more femme when I am more anemic, because I find that I am less likely to find myself in surprise situations where somebody wants to be physically aggressive towards me."* - P1
	Income	*"I do think there are also great ones like Be My Eyes, [which] is free. ... Then you have paid services like Aira, where it's a trained agent on a video, which is great, but they're quite expensive. And it's like, I'm not paying for their program because I can't afford to pay for it for the times that I might use it ... I don't have that disposable income for access."* - P19
	Language	*"Automated captioning is not available for a lot of cultural heritage languages ... Zoom and Ava [don't] work for the other languages that I speak."* - P24

Table 4.3: (Cont.) Instances demonstrating how identity factors related to demographics, community, and activities impact AT use.

Identity Category	**Identity Factor**	**Example Participant Quote**
Demographics (cont.)	Residence	*"We [U.S. residents] have so many options for accessibility tools. But there's so many countries that don't. I went to Jamaica and ... my Deaf friends were shocked to react when I stated that the Deaf children in Jamaica didn't have [videophones] and they only have one certified interpreter in the rest of Jamaica island."* - P15
	Queerness	*"I also with, my gender identity and stuff, sometimes [an AT's style] just doesn't match, like I want. I want my cane to match my outfit when I'm looking hella cute being all trans and loud, like cool, I got a purple cane to go with a wedding outfit of a suit and tux I had at 1 point, because a purple cane would match it perfectly."* - P11
	Race	*"As a Black person, I am a little bit wary about some AI tools. ... I use some at work. But I still limit what I interact with."* - P9
	Religion	*"I grew up with a Catholic mother … there [were] a lot of beliefs around how prayer and priests could cure me out of this very quote unquote unfortunate disease."* - P24
	Size	*"If I'm going to a party or something, and maybe it's outdoors and they have those plastic lawn chairs, there's more odds that I can break that, because it's not going to be weighted for me. Or if I'm going to the doctor's office or something that has seating but all the chairs have arms, now I'm having to squeeze my butt and my hips into this very defined space."* - P11
Communities & Relationships	Disability Community Member	*"I do use my AAC device at a group called [AAC Group Name]. … We meet up and we use our devices for communication. So that's a special community for that."* - P21
	Friend	*"As far as conversations with friends—personal use. I prefer Google Chat. It's a free service rather than Zoom. Zoom limits you to 40 min unless you pay. So I prefer Google Chat."* - P15
	Partner	*'I have a sighted spouse … I used to do all the laundry in the past for a lot of years when I had a manual machine, a more analog type machine. But now it's a little more her responsibility now that we have this machine."* - P16
Activities	Hobbyist	*"I would be an artist, you know. …I felt like I had those wants and talents, but couldn't really express them until, you know, various technologies made certain strides."* - P18
	Athlete	*"I quite honestly looked for a grant for the GRIT chair before we had even saved up money to remodel the bathroom so I'd have somewhere to shower. So it does sort of drive my thinking. But for me I've always, for the most part, been an outdoor athlete."* - P6

Table 4.4: Participants identities and communities they belong to that shape how they use AT.

Identities Related to	**Identity Factors**
Demographics	age, class, disability, education, ethnicity, gender, income, language background, place of residence, sexuality, race, religion, size
Communities or Relationships	disability community member, family member, friend, partner
Activities	being an advocate, a professional, a hobbyist, an athlete

range of technology needs. In Table 4.2, we show a subset of tools used by 8 participants, selected to highlight a diversity of disability experiences. Those with multiple disabilities often needed eclectic sets of tools to meet their needs - for instance the participant in Table 4.2 R5 used braces to support her wrists while using remote ASL interpreting to access phone calls. Some technologies were useful to people with many different types of disabilities; for example, headphones supported screen reader use in public and let neurodivergent participants control their sensory experience without impacting others. While many participants used tools designed for accessibility, other tools not centered around access such as online grocery ordering, voice-activated speakers, podcasts, and Microsoft Teams played critical accessibility roles as well. While we list only notable tools these participants used for access, some described dozens of tools in their hour-long interview.

Participants shared a wide range of identities they hold and communities they belong to that shaped or were shaped by their technology use (see Table 4.4), which we discuss in depth in Section 4.4.4. For example, P9, who is Black, describes needing to code switch while using automatic transcription tools because her mostly Black team is frequently captioned inaccurately. We provide further specific examples of how these factors affect technology use in Appendix A. We highlight that, while demographic identities had a significant impact on participant experiences, so too did identities related to relationships and activities. For instance, P4, who is neurodivergent

and focuses better when audio plays in the background, is mindful of the fact that her spouse, who is blind, relies on hearing auditory information clearly.

4.4.2 Characterizing Types of Access Barriers

Participants used technology to address a wide range of access barriers, which we characterize in Table 4.5. Notably, participants did not only experience access barriers as the inability to do a task without support. Participants described times where access came from improving the experience of performing a task or allowing them to avoid future pain or discomfort. For each type of access barrier we identified in participant experiences, we name it and describe the function of technology in mitigating that type of barrier.

Failure point: a tool makes an impossible task possible

Participants described that, for some access barriers, there was no practical way that they could complete a task without support. We describe this kind of access barrier as a *failure point*.

For example, P3, who uses a wheelchair, explained *"So [my] wheelchair, obviously, is a necessity. It's not an option to go away from it."* Similarly, P17 emphasized *"No matter what, I have to have a screen reader . . . nothing is gonna be done for me without a screen reader."* Without these critical tools, P3 and P17 did not have alternative solutions to approach daily tasks like moving about the world or accomplishing tasks at work. P6 found that only some aspects of a task were failure point barriers – she reflected: *"Can I get dressed without [a dressing stick]? Yes. Can I get fully dressed without it? No. So I can put on my shirt and everything but pants. If I didn't have the dressing stick I wouldn't be able to get pants on."* While she could put on a dress and be ready to go outside, any outfit involving pants was a failure point without her dressing stick.

Table 4.5: Four types of access barriers, the goal of a tool in mitigating each barrier, and examples of participant experiences navigating these barriers with their tool.

Barrier and Goal of Tool	**Example**
Failure Point Tool makes a task that is not possible for a user possible by providing support.	*"So I can put on my shirt and everything but pants. If I didn't have the dressing stick I wouldn't be able to get pants on."* - P6
Usability Barrier Tool helps the user perform a task in a way that is more aligned with their preferences (e.g., faster, slower, easier, harder).	*"If sighted people [are] ordering something, it probably takes like 5 minutes –could end up taking me like 30 minutes, or 20 minutes… longer, always longer. Making [ordering] quicker, probably would be something I would ask for."* - P17
Bodymind Barrier Tool helps adjust the user's bodymind to a more preferred state (e.g., more focused, less pain).	*"If I'm getting dizzy [while watching a video], specifically like, if I'm getting nauseous … I'll still turn on the captioning. But I might just choose to put on headphones instead, and then kind of avoid looking at the screen instead."* - P8
Future Impact Barrier Tool helps provide information that makes dealing with or planning for future barriers more possible.	*"The one I use the most is this 10 minute timer, an hourglass timer, because I don't take my phone in the bathroom, and I shower, and also, I can't hear … I really lose, like all sense of time ... sometimes showering makes me not feel good and like if I've been showering for way too long, like I need to sit down afterwards, and so that [hourglass timer] gives me like a check on [time]."* - P2

Usability Barriers: Technology changes a quality of the task

Participants also experienced access barriers when a task could be completed, but not with the qualities they desired. Technology made these tasks accessible by allowing them to perform the task in a way that better aligned with their preferences (e.g., faster, slower, easier). We describe this type of access barrier as a *usability barrier*.

When describing how technology made their world more accessible, participants often emphasized how using technology meant they could complete a task *better*. For P4, fidget toys meant she

could *"focus better on listening to somebody,"* P18 often views Google Docs on his phone where access is *"a little better"* than on his computer, and P9 found that captions made them feel like they could *"hear [words] better, even with the volume the same."* What 'better' meant to participants varied across contexts, but it is clear that, without certain qualities, a task is inaccessible.

For some, a more accessible experience meant meeting basic usability characteristics. P16 describes how the quality of performing a task can impact accessibility: *"You could give me a web page that's perfectly done with your HTML … you labeled everything right. But you happened to use nothing but links and heading level ones, I can't really navigate that page in any useful way."* P16 is considering a different type of accessibility than discussed in Section 4.4.2. He can technically consume the content of this hypothetical web page. However, with a poor heading structure and an over-reliance on links, it is time consuming and confusing to navigate, making it unusable and therefore inaccessible.

Another way an access barrier could be addressed was by making a task mentally easier or reducing cognitive load. Several participants used captions to communicate and, for many of them, while communication without captions was possible, it was far more mentally draining. P7 has auditory processing issues related to their neurodivergence, and finds when video call meetings at work do not have captions and multiple people are speaking at the same time, *"[it] just feels very overwhelming. Like, to a certain extent, my brain just shuts down... it feels very hard to engage in those spaces, because it all just kind of sounds like garbled noise, and there's not really a way to translate it."* Captions enable them to more fully participate in meetings because they do not have to devote cognitive processing to decoding audio.

Bodymind Barriers: Technology changes the state of the bodymind

For many participants, the accessibility of a task depended on the state of their bodymind. An access barrier arose when their bodymind was in an undesirable state (e.g., pained, fatigued,

distracted). We name these types of barriers *bodymind barriers*. To make a task accessible, therefore, they needed tools that helped move their bodymind toward a more preferable state.

A key access barrier that participants expressed was needing to complete a task, but feeling deeply uncomfortable or ill while doing so. Technology, then, helped them move from an uncomfortable state to a more comfortable one, managing symptoms such as pain, dizziness, or fatigue. P10, who experiences both chronic fatigue and pain, makes storage systems for his pain relief technology so that it is always close by and easy to access. P9 describes using a variety of tools to manage their pain while performing everyday tasks in their life. Some, like a monitor and chair, encouraged working in positions that would cause less pain, and others mitigated existing pain, like a massage gun or TENS machine.

For others, access barriers took the shape of significant anxiety or emotional distress around a task. P12, who is neurodivergent, has experienced significant judgment around failing to use the "correct" tone in an email and finds that ChatGPT now alleviates their distress while emailing: *"[Without ChatGPT, I would] continue getting in trouble and or written up for my tonality in emails. I would continue to cry more … It becomes a big, like, pain point for me."* Other participants listed medication as critical to helping them manage their anxiety, depression, or the distress associated with being unfocused (P4, P9).

For many neurodivergent participants, being over- or under- stimulated is an access barrier. P4 works in a quiet office and has found a solution— *"I can't work in silence ... I have my iPad playing [mindless television] all the time [while I'm] sitting at my desk because I have to have that background noise."* P4 desired increased sensory input, but for others, decreasing sensory input was the goal (P7, P22).

Future Impact Barriers: Technology supports people in avoiding or mitigating future impacts

Finally, participants described scenarios where access barriers arose based on the future impacts of doing a task. We call these barriers *future impact barriers.* When experiencing a future impact barrier, a person may be able to complete a task (failure point) quickly or accurately (usability) while feeling little to no distress (bodymind), but they may still consider the task inaccessible because they will experience an access barrier later (e.g., pain, inability to complete an important task, etc.). Tools could help participants address a future impact barrier by helping them perform the current task in an accessible way that avoids the future barrier, or by helping them prepare to deal with the future barrier.

Participants who were blind described situations where they chose their approach to making a task accessible to avoid a future impact barrier. For example, most blind participants sometimes used Aira[1]. Although Aira could effectively remove failure point or usability barriers for a variety of tasks, P18 describes it as *"a last resort, because it's a subscription, and it costs money, and you have a limited amount of time and minutes."* P19 emphasizes the reality that many blind people cannot afford to purchase more minutes: *"I'm also low income. [Technology companies] know that, but they know because there's so few competitors they put the pricing at whatever they want."* Thus, participants treated Aira minutes as a precious commodity; using up their minutes on tasks that could otherwise be made reasonably accessible could leave participants facing future tasks without alternatives. For instance, P16 noted that, while he could use Aira to make sense of his washing machine dial, that would be *"wildly inefficient"*–he instead uses bump dots to mark important settings.[2] Similarly, P18 saves his Aira minutes for higher-stakes tasks, *"especially when it's just not screen reader accessible"* or when under time pressure: *"is this the right train … and I only have*

[1]Aira is a subscription service that allows users to connect to human visual describers using their phone's camera.
[2]A type of durable adhesive dot useful for creating tactile indicators

a few minutes or seconds to figure it out, that kind of last resort thing."

P1 cannot always completely avoid or eliminate a future impact barrier, but self tracking tools have given her enough understanding of her bodymind to better predict, avoid, or mitigate the future bodymind barrier. Tracking migraine triggers and useful interventions *"has enabled me … to make a lot more choices based on the understanding that, instead of staying [inside] in fear of having a migraine, I can react to them when they happen."* Self tracking both enabled P1 to avoid future barriers, by developing a stronger understanding of migraine triggers, and prepared her to better address the bodymind barrier her migraines pose when they occur.

4.4.3 How Tools Interact with Each Other: Repertoires

All participants used multiple tools throughout their daily lives, and they often used tools in coordination. Prior work has identified the fact that accessible tools are often not used in isolation [108, 40, 39, 8, 4]. Desai et al. leverage the framing of *linguistic* repertoires to understand the experiences of multilingual captioning users [39]. To understand the set of tools available to participants and how they utilize their tools we introduce the framing of **technology repertoires.** Through analyzing the technologies participants used, we identify two major types of repertoires: many tools working together to provide access to a single task ("combination repertoires"), and many tools that are tailored to different contexts addressing the same task ("option repertoires").

Combination Repertoires

For some access barriers, ideal access solutions involved using multiple tools together to address the need, which we term a *combination repertoire.* To engage in in-person conversations, P2, who is deaf and hard of hearing, employs a combination of tools that each provide different types of information that allow for greater communication access when used jointly: automatic captions

on her laptop offer both higher accuracy in identifying what words are said and offload cognitive burden; her bluetooth hearing aids offer information on spatial location and speaker identification; and good lighting supports speechreading, which offers more emotional context.

A state-sponsored accessible bus system is P22's key source of independent mobility in her city, but the bus is loud and sensorially overwhelming. She uses a range of tools to help feel more calm on the bus, including wireless headphones to play music, distracting and calming phone games, and a lanyard full of things she can fidget with. These tools each provide a different form of sensory regulation but work together to make loud spaces more tolerable.

In some cases, participants needed a combination of tools at once because multiple access needs arose from different disabilities that impacted the same task. P1 has symptoms triggered by being outdoors and frequently sprains her ankle. To enjoy a walk outside she can use tools like environmentally protective clothing as well as a cane to meet all of the access needs this task poses. Combination repertoires help us understand how participants secure access in complex situations or when needing to meet multiple access needs at once.

Option Repertoires

Additionally, participants described having multiple tools that allowed them to address the same access barrier and were useful in different contexts, which we term an *option repertoire.* P4 describes having *"absolutely tons of fidgets that I play with,"* that can help her focus, and when picking which one to use in a specific context: *"the choice [of what tool I use] comes more from what? How am I participating? And who are the people around me that I may or may not be impacting?"* She explains that social context impacts her tool choice, and she selects quieter fidgets when the noise might bother those around her.

Other participants described building options into their repertoire because it made them feel more prepared. For example, there are many apps that aid in non-visual navigation, but they rely

on having a charged phone. P18 described how he purposefully plans so that: *"if I can't do it [with technology], I have plan B, C, and D… if the sun's out, I could tell you north, west, east, or south by going outside and knowing the time of the day, and not necessarily pulling out my compass on my iPhone."* Having a technology repertoire that allows participants to complete the same task in myriad ways provided security and confidence that, regardless of circumstance, they would be able to make that task accessible.

Some participants observed benefits from mixing repertoire types. When P19, who is blind, wants to know what is in a photo, she considers the **options** at her disposal: the input of sighted people, paid visual interpretation services, or AI tools. She describes that an AI photo identification app would be most useful when: *"I don't want to pay for [that photo to be identified], or I don't have someone available, or it's a private picture that I don't want somebody else seeing."* However, she often then **combines** multiple AI tools to get a more accurate description. This strategy is particularly useful because descriptions are inconsistent–she found that different AI apps *"kind of describ[e] differently between, like different races or ethnicities or skin color."*

Trade-offs and Gaps in Repertoires

At surface level, a larger, more complete repertoire might seem ideal. However, participants described challenges in managing a large repertoire and finding tools that would complete their repertoire due to a lack of available options.

Participants encountered significant trade-offs between having few multipurpose tools versus many bespoke tools. For some, an abundance of technologies could be expensive and hard to manage. P16 explained that, when considering acquiring a new tool, he asks: *"how much does it weigh? How much space does it take up? How much of a goofball do you look like carrying a gigantic backpack just to go down the block, because you have all your devices and cords and whatnot?"* On the other hand, P10 celebrated having a wide range of tools on hand that served very specific

purposes. P10 is a maker and crafted his house so that he could access his repertoire effectively, including 3D printing custom holders to organize his many tools.

Participants also described ways that their repertoires were incomplete or insufficient. P21 uses a large number of adaptive tools to try to make everyday activities, such as cooking, folding clothes, and drinking from a cup possible for her. Despite the effort she and her occupational therapist have put into finding helpful tools, she still lacks independence in many of these areas. She reflected that *"it's gonna be really exciting when I find the right tools to help me really succeed in my daily life."* P21's repertoire remains incomplete and access barriers persist because no commercial solutions fit her needs.

4.4.4 What Influences Technology Choice and Use: Contextual Factors

A final major driver of accessibility is *contextual factors*: the characteristics of a person, their tools, or their environment that can influence their experiences of inaccess or moving towards access. Participants described contextual factors connected to their identities (e.g., race, gender, class) and situational context (e.g., location, availability of disability services). Many of the contextual factors we identify are connected to systems of power–forms of marginalization often dictated how participants could approach access in their day-to-day lives. We identify two major functions of contextual factors: determining what tools participants have in their repertoires and changing their experiences of using those tools.

Contextual Factors Shape Technology Repertoires

First, characteristics of tools, situational context, and identities shaped what tools participants could or chose to include in their repertoires.

Technology Characteristics. Qualities of assistive tools themselves were a preliminary factor

Table 4.6: Instances demonstrating how non-identity factors related to social contexts, spatial contexts, and institutional supports and barriers impact AT use.

Non-Identity Category	**Non-Identity Factor**	**Example Participant Quote**
Social Contexts	Relationship to Person I am Interacting With	*"[It depends if I'm communicating with] someone who I am like, really familiar with speaking with and like, I'm usually like able to communicate with them about captions. And we have like established processes. Or maybe they know sign right?"* - P2
	Social Perceptions	*"I'm a bit resistant to using assistive technology. I think it also comes from the negative connotation and the stigma around disabilities that I grew up with. So, the culture and the society kind of views disability in a ... very negative way."* - P3
Spatial Contexts	Location	*"At home, I definitely have more access, like, my massage tools are definitely kept at home and stuff. But I do have a small massage roller that I carry in my purse when I'm at work and I have [an] arnica oil that I use that I can bring with me to work and stuff. I can do some limited stretching at work as well, but definitely have more access at home to really care for myself."* - P9
	Environmental Conditions & Context	*"There are people who can't work with noise. I can't work in silence... I have to have that noise... when I was in when I was in grad school, and I would be sitting in a coffee shop because I had the coffee shop going around me."* - P4
	What's Available in the Environment	*"We didn't have access to phones at the time [while traveling]. So basically [I] was writing notes back and forth with English to family members who are writing in Spanish."* - P15
	What Can Change in the Environment	*"[As someone who is COVID conscious, when] anyone comes into my apartment, I am always masked, and [I] ask them to mask. I have several HEPA air purifiers in my apartment. I will open the windows for ventilation."* - P7
Institutional Supports or Barriers	Bureaucracy and policy (Support)	*"With my case worker, I put in [a request] for ... these special blinds, and you need the Alexa to go with it, so I put in a request to get those special blinds."* - P23
	Bureaucracy and policy (Barrier)	*"[I reached out to see what support] my local regional center would provide. But I was told … you only qualify for services if you're considered like moderately to severely [autistic] I think they use some kind of like functioning label or something like that. And so I was just like, okay, I don't think I'm going to qualify for this, because, like as it is like people already, don't believe that I'm autistic."* - P8

Table 4.7: Four synthetic scenarios deconstructing AT decision-making by: (1) illustrating access barriers; (2) identifying barrier types, contextual factors, and AT repertoires; (3) applying consequence calculus; and (4) arriving at an access choice to complete tasks accessibly.

Scenario 1: Benji, who is non-speaking	
Access Barrier	When going on a first date, Benji needs a way to communicate, without relying on support from her usual communication assistant: her mother
Identify	**Type:** Failure Point **Contextual Factors:** Social expectations; Prioritize independence **Repertoire:** AAC device
Consequence Calculus	1. Benji could suggest going to a movie, where they would not communicate much 2. Benji's mother could come along to facilitate communication 3. Benji could use AAC to communicate with her date
Eventual Access	Option 3 is by far the best option for Benji–she wants to get to know her date and does not want her mother along
Scenario 2: Jordan, whose left leg is amputated above the knee	
Access Barrier	Jordan's current prosthetic makes walking very slow, and she is looking to upgrade to one with a powered knee, allowing her to walk faster
Identify	**Type:** Usability **Contextual Factors:** Jordan is a Black woman; She is a lawyer and has a dress code at work; The upgraded prosthetic she is looking at only has a pale beige cosmesis; She could forego a cosmesis, but it will look bionic **Repertoire:** Current prosthetic, New prosthetic with powered knee, pale beige cosmesis
Consequence Calculus	1. Jordan can continue using her current leg, which matches her skin tone, but is tedious to walk in 2. Jordan could get the upgraded leg in beige, which will not honor her racial identity and will make her feel self-conscious while she wears it 3. Jordan could forego a cosmesis, and have a more obvious prosthetic leg
Eventual Access	Jordan chooses option 3– having a leg that allows her to keep up with her friends while working is worth it, and, while she does not enjoy how obvious it is that she is an amputee, it honors her identity as a Black woman better than pale beige would

Table 4.7: Four synthetic scenarios deconstructing AT decision-making, continued.

Scenario 3: Alex, who is Deaf	
Access Barrier	Alex is on a road trip with their friends, and they just walked into a loud restaurant – after a long day in the car, communication is cognitively overwhelming
Identify	**Type:** Bodymind **Contextual Factors:** Alex and their friends are notably queer; The restaurant is in a conservative, unfamiliar area; They and their friends know ASL; It's been a long day, and everyone is tired and ready for food and bed **Repertoire:** Hearing aids; Automatic captions; DoorDash
Consequence Calculus	1. Everyone in the group could sign through dinner, enduring further feelings of being out of place in this restaurant 2. Alex could "power through" dinner, enduring feeling overwhelmed and unable to join in conversation 3. The group could go to their hotel instead and order dinner on DoorDash
Eventual Access	Alex chooses option 3: they ask their friends if they would feel okay driving back to the hotel and ordering DoorDash instead – everyone agrees and opts for a quiet night in
Scenario 4: Juan, who has a visual processing-related chronic health condition	
Access Barrier	Juan's team at work is sitting down to read a printed document – he is able to read it visually, but doing so will make him very dizzy and nauseous within the hour
Identify	**Type:** Future Impact **Contextual Factors:** Social acceptability: Juan will be notably different than his coworkers if he puts in headphones to listen to a text-to-speech (TTS) tool; Everyone will be reading this document in 10 minutes or less; Juan has high familiarity with people on the team from previously working together. **Repertoire:** Headphones; Laptop with TTS; A PDF of the document; A printed copy of the document
Consequence Calculus	1. Juan can visually read the document in full and probably won't be too dizzy or nauseous before the meeting is over, but the rest of the day will be hard 2. Juan could skim the document, maintaining social acceptability and not getting too dizzy, but he misses out on potentially necessary content 3. Juan could pull out his laptop and read the document using TTS and headphones, risking the social consequences
Eventual Access	In this meeting, which includes only teammates he has worked with for years and no clients, Juan chooses option 3: his team understands his access needs by now, minimizing his concerns about social acceptability

in determining their utility. Many properties of technologies that participants saw as important are well-represented in prior literature: performance (e.g., accuracy, efficiency) [46, 85], durability [28], ease of use [12, 28, 111, 6], and system requirements (e.g., battery life, Wi-Fi, portability) [28]. Participants emphasized the importance of these characteristics, with P19 explaining: *"I live on a sailboat... and so I won't always have access to the Internet. And so many of these apps like barcode readers with SeeingAI, and these different features rely on the Internet."* Whether or not a tool could function without Wi-Fi was often the deciding factor in whether or not P19 used it.

Identity Characteristics that Limited Tool Options. Participants who held minoritized identities often had less access to tools or supports, due to pervasive oppressive systems.

Many tools are prohibitively expensive, a reality P20 faces as he figures out how to make his life accessible to him as a quadriplegic wheelchair user. P20 and his partner moved to an accessible apartment with a collection of tools they were only able to purchase with the financial support of family and friends. Still, a bed that could limit how much he needs to be turned in the night remains in storage because their apartment elevator is not big enough to fit the bed and moving to another accessible apartment is too expensive.

Accessible technology availability is not only limited by cost, but also by structures that shape who can access and learn to use those tools. As P8 began to understand themself as autistic, they sought support from local services, only to be turned away because in their area *"you only qualify for services if you're considered, like moderately to severely [autistic]."* While funded services existed, P8 could not access them because of documentation requirements. Other participants could access well-developed support services, and demonstrate their value. P18 became blind at three years old, and from the time *"they gave me a cane at the age of four"* he received consistent orientation and mobility training. He reflected on the impact of his parents' dedication to encouraging his independence: *"I attribute a lot of my exploration and experience to that, and having a good support system."* Participants raised in households with disability stigma, on the other hand, had less

access to technology at formative ages. P21 grew up with parents who believed that it was *"very shameful to have a child with disabilities"*, which has left her to develop her accessible technology repertoire for the first time in adulthood. In these examples, a host of contextual factors including cost, disability services policy, and family beliefs could all keep useful tools out of a participant's repertoire.

For some participants, available tools did not get added to their repertoire because contextual factors made them functionally unusable. When P2 communicates in English she regularly uses automatic captioning, but the language her family communicates in is poorly supported by automatic speech recognition. Her relationships with her family are impacted by the fact that, without usable captions, *"I don't have the support I need in this context to maintain touch."* Safety was also a significant factor that eliminated tools from consideration. P25 worried about being perceived as weak and vulnerable when out in his community, so chose to not use a white cane because *"I'm one that don't like to be taken advantage of, and I'm not going to invite it to me."* P19's spatial context is dominated by the fact that she lives on a boat – unlike many blind people, she cannot use organizational tools that depend upon things staying in a consistent place in her home. Contextual factors, such as language or perceived safety, could make even available and commonsense tools unusable to participants.

Contextual Factors Shape Experiences Using a Tool

Contextual factors also shape accessibility through their impact on the experience of using a tool. While many participants experienced contextual factors that made tool use less comfortable, some found that tools could engage meaningfully with other factors in their lives.

Participants described instances where contextual factors made tools less comfortable to use. P10 is an activist and mindful of his privacy, so, when he can, he only uses transcription tools that do not record or share data. However, when talking to a friend who relies upon transcription

tools that store data, he concedes to being recorded because there are no better options. For some, limited technology options do not consider their identities. P5, who is African American, uses braces to manage and prevent injury, but finds that *"the beige or 'skin tone' for braces has never fit my skin tone."* Participants also sought to express their gender identity more fully but were limited by the lack of stylistic variety in apparel that is made to fit people who use wheelchairs (P5) or UV protective apparel (P1). When a tool is not designed with attention to the diversity of disabled people, many are left without tools that match their whole selves. Much of the time, P7 benefits significantly from using noise-canceling headphones for sensory regulation. However, when in a public context, they often forego using headphones because it *"put[s] me at risk of being unsafe and feeling like I constantly have to be vigilant... [to] protect my safety as a queer and trans person of color."* Especially for people who are multiply-marginalized, technology does not always afford them greater safety when moving through the world.

At the same time, participants also described times where technology use honored or engaged deeply with their identities, communities, and other contextual factors. As she manages a serious skin condition, P24 has found technologies that can connect to her cultural heritage: traditional herbs. She recounted taking *"really strong, bitter herbs for, like, over 10 years"* as a child, and felt that they *"really got me through when Western medicine was not it."* Being able to engage with a tool connected to her culture is *"just really like soothing for me. Physically and emotionally."* For P21, her technologies allowed her to build up an identity that had otherwise felt out of reach. After months of meetups where all communication is AAC-mediated she *"feel[s] empowered and enlightened and hopeful for my success as an evolving AAC user and the possibilities for me really becoming a true communicator."* For P11, tools offered opportunities to further express their gender identity: *"I want my cane to match my outfit when I'm looking hella cute being all trans and loud."* One of the reasons P12 has found ChatGPT so useful in their daily life is that it uniquely honors their identity. They explain that ChatGPT *"has never misgendered me. Unlike myself, or unlike*

my friends, like in general . . . it adjusts everything for me." Though it could be more difficult to find tools that aligned with all the contextual factors in a participant's life, when that alignment occurred, technology use could be a source of empowerment and connection.

4.5 Modeling Accessibility

Having named the variety of access barriers participants face (Section 4.4.2), the range of tools they use to address access barriers (Section 4.4.3), and the contextual factors that shape how they experience accessibility (Section 4.4.4), we now knit these findings together to synthesize a process for *modeling accessibility.* We articulate the key inflection points for modeling accessibility: describing an access barrier; taking stock of the repertoire at hand; and understanding the contextual factors that shape the repertoire and experience of the access barrier. As demonstrated by the synthetic example of Riley in Figure 4.1, once a person customizes this generic model (by considering their access barrier, repertoire, and contextual factors), and performs consequence calculus to determine a path forward, they have created a personal, contextual model of accessibility.

4.5.1 Assessment of the Scenario

When someone has an inaccessible experience, there are a multitude of influential pieces of information at play, which we diagram in the "assessing the situation" stage of Figure 1. One of these pieces is a fundamental description of what the access barrier is (e.g., I am feeling too much pain while completing this task, experiencing a bodymind barrier). Another is the tools, or repertoire, available that could address this barrier. And the final, critical information is relevant contextual factors including identities, characteristics of the tools, and other situational factors.

Together, these factors characterize the experience of inaccessibility and are inseparable. For example, the context of a person's identities can impact how they define their experience of an

access barrier. A person who is low income might necessarily scope their repertoire to not include an expensive, motorized wheelchair of any kind, making independent movement a failure point for them. In contrast, someone who can purchase a very slow, old motorized wheelchair may face a usability barrier. Further, what someone fundamentally defines as a barrier might change based on the context or their positionality. P13, who is hard of hearing, often does not view herself as experiencing a communication access barrier at optional social gatherings, since she is a self-described introvert and would prefer not to interact with people.

4.5.2 Consequence Calculus

Having identified the type of access barriers, available tools, and relevant contextual factors, the next inflection point in modeling accessibility is the decision making process, which we call **consequence calculus**. We adopt the term consequence calculus from Mack and McDonnell et al. [99], who define it as a process by which *"individuals determine what is inaccessible to them at a given time based on deeply personal and contextual factors."*[3] Participants describe processes, often second nature, where they consider the tools available to them and the context at hand, identifying the available paths to mitigate their access barrier and selecting the one that best matches their priorities in the moment. Notably, this calculus was limited in instances where users had no or only one feasible option for making a task accessible. Yet, accessibility often required engaging in a complex calculus to choose the optimum of many paths forward. Importantly, the optimal path for an individual is not always the path that looks most obviously accessible—access is often one of many priorities an individual is weighing given the contextual factors surrounding the decision. The emotional experience of using a tool–whether it honors someone's identities or excludes them–may supersede considerations of performance.

[3]Paymal and Haywood [122] have also explored how consequence calculus illuminates how people choose technologies, specifically in the case of people with ME/CFS

To demonstrate consequence calculus, we turn to P11's experience deciding which mobility aids to use while shopping. As a person with a chronic illness that limits energy and causes pain, they choose between the tools in their repertoire when going shopping: using a store's motorized shopping cart, their own rollator, or not using any mobility aid. Each choice presents trade-offs. For motorized carts, they report considering: *"What happens if it runs out of battery? Now I'm stuck in the store."* Their own rollator is more reliable and is rated to hold their weight, which is not true of all chairs. However, P11 notes that *"when I'm using my rollator, I can't use a cart because my rollator requires two hands"* and they describe having to expend energy getting it in and out of their car. As someone who has the *"privilege of being an ambulatory user"* they also can choose to do a quick trip without mobility aids— they sometimes decide: *"I know this is going to hurt my body, but I'm going to make it quick."* In other instances, consequences are differently weighted, illuminating how the motivation for their trip shapes which tool they choose. For example, P11 describes considering: *"am I going there because I need to pick up something for this [activist] event I'm going to? Or am I going there for me?"* Notably, this decision-making process is complex when decomposed, but P11's embodied expertise makes it something they describe as *"a quick cost-benefits in my head."*

Following consequence calculus, individuals make a decision about how to move forward in addressing an access barrier and finding a way to complete the task accessibly. We demonstrate the full process of modeling accessibility (assessment through consequence calculus through decision) in Table 4.7, in which we deconstruct this decision making through four synthetic scenarios derived from experiences participants described.

4.5.3 Access: A Summative Example

Finally, to demonstrate the richness and fluidity of a person's experience with access, we model one participant's experience of accessibility at three different points in time as he developed his repertoire for a single task. This example highlights how one model of accessibility does not necessarily characterize a person's experience outside a single point in time; a person's model can change drastically depending on the type of access barrier, their repertoire, and relevant contextual factors.

Experiences with a Limited Repertoire

P3 is a person with an acquired mobility disability that impacts hand dexterity. He enjoys a nice glass of wine, and after his injury he wanted to find a wine opener he could use. At first, his repertoire consisted of only a traditional wine opener (corkscrew), which required *"all the hand abilities which I don't have."* He explains that it took *"45 minutes to open a wine bottle... I've gone through that a couple of times, obviously it's not very practical."*

When modeling P3's experience at this point in time, we see that his repertoire was limited to a traditional corkscrew. With this corkscrew, he experienced a usability barrier; he could open the bottle of wine, but only after 45 minutes, which he (understandably) described as tedious and therefore inaccessible. Depending on the contextual factors at play on a given night, he might perform consequence calculus and decide to wait for his friend to arrive to open the bottle or, if he's alone, he might opt for a different drink.

Expanding the Repertoire

P3 desired a faster way to open a bottle of wine himself. Consequently, he tried out other wine opening tools, seeing if there was one he wanted to add to his personal repertoire. Contextual

factors shaped the kind of tool P3 is most comfortable trying. When looking for a tool, he explains that he weighs the potential impact of stigma, often feeling that using explicitly assistive tools will make it so that he will *"just be standing out all the time, and I don't want that"*. He reflects that his identity as someone who grew up in a non-American culture with a *"negative connotation and the stigma around disabilities"* likely influences his reluctance to use assistive technologies. This perspective extends into how he chooses tools for his repertoire; instead of buying a tool explicitly branded for people with disabilities, he often seeks out mainstream tools first.

Yet, even after finding a mainstream tool that might be useful, trying new solutions was not always a smooth process. Whether or not he is willing to test out a new tool *"depends on my fatigue level at that moment or day, or how my frustrations have been with doing one or the other in the past."*

To model P3's experience trying a new wine opener on a night he is feeling fatigued: he faces a bodymind barrier. He may be too tired to try using the new tool. Since the task at hand is to independently open the bottle of wine with the tool to test how long it takes, relying on someone else to open the wine is not an option. His consequence calculus might point towards postponing the task of testing the new tool to another day.

After Expanding the Repertoire: Access

After trying multiple options, P3 found a tool *"where you have to just press a button and goes in and just takes out the cork, and that works great for me."* While using this tool, he finally achieves access he is satisfied with. To model this experience, the barrier is a usability one–opening the wine bottle without this new wine opener is technically possible, but not *practically* possible. However, with this tool in his repertoire, P3's consequence calculus is simple–he chooses to use the electric wine opener, which does not carry stigma and makes the task easy.

4.6 Discussion

Our findings demonstrate a variety of possible access barriers disabled people may face, highlight the role of technology repertoires in shaping access, and emphasize that contextual factors are central to experiences of accessibility. We have synthesized these findings into a process for modeling accessibility, which articulates the assessment and consequence calculus that allows an individual to move from experiencing inaccessibility to experiencing accessibility. We now connect our findings to prior work and highlight opportunities for design.

4.6.1 Connections to Other Accessibility Paradigms

Our results highlight that accessibility and access provisioning are deeply influenced by contextual factors, regardless of the type of access barrier or technologies used. We compile contextual factors discussed by participants in Table 4.6, identifying identity and non-identity factors. Ours is not an exhaustive list and other repositories enumerate additional contextual factors that impact tool choice [28, 63, 25, 136]. Although the scope of our interviews focused on *technology-supported* access provisioning, Bennett et al.'s interdependence framework also broadens the context in which accessibility provisioning operates [8], highlighting the role other people play in enabling access. Finally, consideration of social factors further emphasizes the relevance of Shinohara et al.'s paradigm of *social accessibility* [145, 146].

Further, we bring our types of access barriers into conversation with Mack and McDonnell et al.'s "consequence-based accessibility." They expand understandings of inaccessibility to include situations where someone will incur considerable negative consequences from performing a task, and introduce consequence calculus as a method for managing those consequences. Our characterization of types of access barrier builds on this work, and many of the barriers they describe map across our bodymind and future impact barrier types. We also argue that their

formulation of consequence calculus is applicable across types of access barriers and relevant to disabled people beyond those with chronic illnesses.

While we contribute an explicit classification of types of access barriers, accessibility research has been conducted addressing all four types of barriers. We identify prior work mitigating failure point barriers (e.g., [86, 51, 50]), usability barriers (e.g., [12, 70, 158, 94]), bodymind barriers (e.g., [133, 21]), and future impact barriers (e.g., [122, 80]). By explicitly naming these access barriers, we enable retrospective analysis of bodies of work and hope to guide future researchers to a clearer articulation of the access barriers they address.

4.6.2 Design Implications

Our results surface new insights for designers and researchers around 1) identifying new research and design spaces and 2) improving specific tool designs.

Putting Modeling To Use.

Having articulated a process for modeling accessibility, we envision myriad possible applications. Fundamentally, we envision our modeling process as a method by which accessibility can be more specifically named, understood, and decomposed. While well-suited to fundamental research into accessibility, this process could also support technology designers, policy makers, and people with disabilities themselves. Future work could explore whether our modeling process could be used as a form of structured reflection on disabled people's experiences of accessibility, either to support their own exploration and self-knowledge or to structure information gathering for researchers, designers, and policy makers. Furthermore, our process highlights how complex accessibility is in disabled people's daily lives, indicating a need to support disabled people in making sense of and meeting nuanced accessibility needs. Our model could be used to support structured and rapidly

changing explications of access.

Identify Under-Served Identity Intersections.

Our results highlight that non-disability identities are tightly intertwined with accessibility. Echoing Hamraie [61], we highlight that if researchers and designers do not consider the range of identities the future users of an accessibility tool may hold, they risk considering only the most privileged and further perpetuating structural inequities. For a tool to be practically useful, it should support a person's other identities as well as their access needs.

Many existing tools do not adequately consider minoritized non-disability identities, such as being a person of color, queer, or low income. Consequently, some participants felt the need to compromise their identities to use a technology, and some forewent using tools altogether. We highlight opportunities for future research and design to better serve disabled people who hold multiple minoritized identities. Furthermore, participants valued opportunities when their non-disability identities were honored and expressed through their assistive technology–future work should consider how to not only avoid harm but enable joy.

Utilize Barrier Types and Consequence Calculus to Reveal Unsolved Problems.

Barrier types and consequence calculus can provide a new understanding of the problems addressed by existing tools, and can reveal problems that are not adequately covered. Perhaps, when viewing a task through a failure point model, it may seem like a person with a disability can perform the task. But, when viewed through a lens of a usability barrier, it becomes clear that there are no solutions that let them do so quickly or easily. For some barriers, it may be impossible to prevent all negative impacts (e.g., a task may either be fast and painful or very slow but pain-free). In these cases, engaging with an individual's consequence calculus can reveal which types of support may be most useful.

We now highlight how considering design spaces through the lenses of each of the four types of access barriers we articulate reveals new goals and opportunities.

- Failure point barrier: create a solution that allows a person to accomplish a task they could not otherwise do. Often, a failure point results from a lack of a feasible solution in the problem domain, which can produce a very broad, rich design space. However, designers should be cautious not to create disability dongles [76, 75], as the absence of an existing "solution" could be explained by the problem being insufficiently motivated.

- Usability barrier: create a solution that improves some dimension of performance for a user on a task. This motivates investigation of which dimensions are well-addressed by existing tools, as well as which unaddressed dimensions sufficiently motivate a new tool. Designing for usability barriers highlights that technical but onerous solutions are not sufficiently accessible.

- Bodymind barrier: aid the user in performing a task in a more desirable state (e.g., less pain, improved focus). A first step might be working with disabled individuals to understand the discomfort or difficulty they experience while performing a task. Then, while some solutions might focus on altering a person's bodymind (e.g., a brace, medication) other solutions may aim to create a more sensorially tolerable environment (e.g., changing the lights, temperature).

- Future impact barrier: make it so that a person can perform this task in a way that avoids or mitigates negative future impacts. Two paths from which to approach this problem space include: 1) changing the original task to avoid incurring the future cost (e.g., avoid triggering a migraine) or 2) mitigating the access barrier that arises in the future (e.g., make future tasks more comfortable to complete with a migraine).

Consider Multiple Sites of Change.

Accessibility research has traditionally designed tools that improve accessibility by changing an individual's environment or interactions with their environment (e.g., [79, 37, 92]). Yet, we highlight the possibility to design tools that directly or indirectly create access by acting upon an individual's bodymind. Accessibility and disability studies scholars have traditionally attempted to distance design efforts from an appearance of attempting to cure or fix disabled people [103, 113]. Yet, participants described the value of changing their bodymind in ways that centered access, not cure. We call on the field to consider ways to design thoughtfully to enable individuals to change their bodyminds as they desire.

Consider New Goals a Tool Can Meet.

Novelty is highly valued when designing and researching new potential accessibility tools. However, attending to the ways that people use tools as part of a repertoire reveals opportunities for researchers and designers to revise assumptions around how novel a tool must be to be useful. Participant use of option repertoires demonstrates that disabled people will use different tools for the same access need depending on the contextual factors at play. Therefore, the presence of an existing tool that addresses a specific access need does not necessarily negate the value of more tools to address that need in different circumstances. For example, a solution that accomplishes a task without needing wifi could be a valuable addition to people's option repertoires, even if they already have tools that accomplish that task when using wifi.

Furthermore, considering combination repertoires can redefine the necessary function of a new technology. If tools are designed to fit within combination repertoires, they may be useful without addressing the entirety of an access barrier. However, researchers and designers must take care to ensure that new tools still meaningfully address access barriers to avoid creating

superfluous or incomplete solutions.

Design for Interoperability.

When designing accessibility interventions, researchers and designers should move to consider how tools will operate within an individual's repertoire. To do so, tool designers must first understand the landscape of technologies that their target audience likely own and use. Designers should then consider how tools can complement and be used alongside other elements of the repertoire. Furthermore, recognizing the constraints that a tool imposes on a repertoire could increase the possibility of it being practically useful and decrease the odds of abandonment. For example, a tool designed to be used while a white cane user navigates must recognize that a white cane requires one hand to be occupied while navigating.

4.6.3 Limitations and Future Work

Our study has several limitations and identifies opportunities for future work. First, our work is scoped to a western- and US-centric perspective. As global definitions and experiences of disability vary [10, 153, 128], we expect that different facets might come into consideration when modeling accessibility. We encourage future work to consider more globally contextually-specific models of accessibility. Second, we define accessibility in terms of an experience performing a task, whereas there might be situations that are ill-formatted as task-driven (e.g., enjoying the sunset). Third, we acknowledge that the identities of our research team are not fully representative of the participant communities whose experiences we analyze (e.g., disability and racial identities), which may influence how we interpret their experiences with (in)access. Further, participant disability identities skewed heavily towards people with neurodivergence, chronic illnesses, or mental health conditions, though many of these participants held other disability identities as well.

Our modeling process may disproportionately represent the needs of this subset of the disability community. Fourth, we model accessibility assuming the existence of an already-articulated access barrier. Future work modeling how inaccessibility comes to be would be an exciting complement to this work. As we have identified the role of contextual factors in shaping the experience of accessibility, we suspect that they are also central to how access barriers arise and are felt by disabled people. Fifth, our interview and analysis were scoped to access provisioning that utilizes technologies. Prior HCI research and accounts of lived experiences of disabled individuals highlight the importance of personal and social supports in achieving access [10, 153, 128]. We emphasize that while these efforts were not in scope for this project, they are important, and not wholly out of the conversation with our model; social solutions could be well-integrated into consequence calculus and should be explored in future work. Finally, we do not intend for our lists of types of access barrier, repertoires, or contextual factors to be complete or immutable. We list these types, repertoires, and factors that were well represented in our dataset, but we anticipate that by applying our model to more contexts, more will be named.

4.7 Coda: Returning to the Game of Accessibility

As we conclude this chapter, let us again return to our ongoing discussion of the Game of Accessibility. An entering goal of this work was to develop a richer understanding of the interaction between people with disabilities and access barriers. Our resulting model surfaced new insights on what challenges barriers pose, what factors affect the interaction, the approaches people can take in the interaction, and the process of deciding what approach to take. All of which are integral to our evolving model of the Game of Accessibility.

4.7.1 Barrier Types and Difficulty

First, we can consider how our categorization of barrier types (Section 4.4.2) can support stronger articulation of challenges presented to a "player" in the Game. The conflict between player and barrier is fundamental to our definition of accessibility as a game, and so by identifying distinct types of barriers, we can begin to more accurately describe and model what challenge is being presented to the player. By more meaningfully describing the challenges in the Game of Accessibility, we can then apply our existing understanding of concepts like difficulty and demand (see Section 2.4.2) to generate novel insights.

One particularly interesting application is considering how Jagoda's three types of difficulty in games [77] interact with our four types of barriers. To briefly restate the types of difficulty: *mechanical difficulty* describes the challenge of successfully executing bodily actions (e.g., reaction time challenges or precise targeting); *interpretive difficulty* describes the challenge in determining how one progresses in the game (e.g., figuring out how to combine existing tools or solving environmental puzzles); and *affective difficulty* describes the challenge of engaging with the emotions evoked through gameplay (e.g., managing fear in a horror game or processing frustration when failing). Within each barrier type, we can consider how our types of difficulty might manifest to better characterize the qualitative experience of engaging with a barrier.

Failure point barriers have a strong relationship to mechanical difficulty, as these barriers are often due to a direct mismatch between what actions a person can perform and what actions the situation demands. However, there is also interpretive difficulty in attempting to find workarounds to bypass a failure point, and significant affective difficulty posed by the experience of being prevented from doing something.

Usability and bodymind barriers, on the other hand, are perhaps more strongly characterized by interpretive and affective difficulty. In both cases, the specific task *can* be performed (meaning

mechanical difficulty and execution are not the predominant issue). However, finding a new way to perform a task (usability barrier) or managing an undesirable physical/mental state (bodymind barrier) presents its own type of difficulty, which more closely maps onto interpretive and affective difficulty.

Finally, future impacts barriers exist somewhere across the types of difficulty. The initial task is completable, but may have later consequences that pose new mechanical difficulty (e.g., if a person is too fatigued to do an otherwise unchallenging task); predicting consequences and determining whether or not the outcome is "worth it" is a form of interpretive difficulty; and the emotional experience of having to do this calculus and knowingly incurring consequences to oneself certainly presents an instance of affective difficulty.

4.7.2 Repertoires, Calculus, Context, and Gameplay

Our model also contributes several factors that add important complexity to how we consider the process of navigating a barrier. Repertoires (Section 4.4.3) describe how having multiple tools determines a person's options for navigating a barrier, contextual factors (Section 4.4.4) inform what specific outcome is desired when navigating the barrier, and consequence calculus (Section 4.5) characterizes the final decision-making process. These concepts directly tie to a variety of game studies concepts, including metagaming, identity-based gaming, and the space of possibility.

The space of possibility (see Section 2.4.3) characterizes what possible interactions can occur within a game, as defined by the mechanics and boundaries created by the game's designer. Analogously, we can consider the set of tools available to a person (i.e., the repertoire) as variables that define the "mechanics" within the Game of Accessibility: the range of approaches a person can take to navigating a barrier is constrained by the set of tools available to them and how they

interact with the barrier. Thus, we can roughly model the space of possibility as a function of a person's repertoire and the specific barriers in the game.

For instance, consider how the space of possibility changes for a hard of hearing individual with a repertoire consisting of either hearing aids, lip reading, or both. When solely relying on hearing aids, noisy environments (e.g., a crowded bar) might be fully inaccessible and therefore "outside" the individual's space of possibility. If relying solely on lip reading, contexts where a person's mouth is covered (e.g., settings where people are wearing face masks) are similarly outside the space of possibility. However, with an option repertoire including both hearing aids and lip reading, neither context is excluded from the space of possibility, and the game can continue on beyond both of these settings. This framing forms the foundation of what I have come to term the "*accessible* space of possibility", which is discussed further in Section 6.3.

Metagaming and identity-based gaming (discussed in Section 2.4.4) also relate to our discussion of contextual factors and consequence calculus, in part by building on this foundation of the space of possibility. Both metagaming and identity-based gaming center the concept of independent determination of goals within a game, allowing individuals to play in a way that specifically aligns with their values and desires, rather than defaulting to a playstyle dictated by the game designer or player community.

This aligns very neatly with our framing of contextual factors related to accessibility decision-making. Contrasting other models of accessibility that presume a single "most accessible" outcome, our model emphasizes that an individual's values can influence what actually is considered the best option. Similar to how a metagame can change what a player's win condition is, so can contextual factors and individual identity and values in the Game of Accessibility.

Chapter 5

Hard AT Work: Informational Needs in AT Adoption

During the process of working on *Modeling Accessibility*, our team identified that our interviews provided interesting insight into how participants first started using their AT that was not explicitly relevant to that study. We also had developed our process for modeling accessibility (which I have come to call the 'calculative model'), which notably formalized this concept of an AT "repertoire," or the unified set of tools PWD use when navigating access barriers. This pointed to one outstanding question: *what does the process of AT Adoption actually look like, and how can we support it?*

This project was also designed to leverage insights from both *Modeling* and *Hard Mode*, bridging the three projects in this dissertation. This involved revisiting the three-stage model of tech adoption from *Hard Mode* and connecting it to repertoires and AT acquisition from *Modeling*. This bridging also carried into the study itself: a portion of the data analyzed was from *Modeling*, and the qualitative analysis method was based on the analysis in *Hard Mode*.

This project has not yet been submitted anywhere, but is intended to be submitted soon to a relevant HCI/Accessibility conference.

5.1 Introduction

Access technology (AT) is often central to how people with disabilities (PWD) navigate the world, and as the technological landscape constantly evolves, so does the space of AT that can be used to navigate access challenges.

However, despite ample research about the *design* of AT, there is much less work exploring the actual process of *adopting* AT, from first learning about a particular technology to actually learning to use it and incorporating it into one's life. In prior work, I explored the process of *game* adoption for disabled gamers [105], which employed a three-stage model of accessible game adoption based on Lee et al.'s prior work on how people make sense of video games as information objects [91].

Extending the three-stage model to cover more than just games, we can now use this framing to discuss broader processes of technology adoption for PWD, including three central phases:

1. **Discovery.** Finding out about a new technology, but not yet investigating its specifics

2. **Evaluation.** Assessing the "fit" of a technology, in particular how it aligns with a person's access needs and whether it will serve the desired purpose.

3. **Adaptation.** Integrating the technology into one's repertoire (see [101]), including learning to use it and potentially modifying the tool or how it gets used.

This work is guided by two primary research questions:

1. How are PWD currently navigating the process of AT Adoption?

2. What informational needs are most prevalent in AT Adoption, and how effectively are these needs met in current systems?

5.2 Methods

5.2.1 Preliminary Interview Study: Acquisition Methods

The first portion of this work leveraged unused data from the Modeling Accessibility study (Chapter 4). In the original study, we interviewed 25 participants with a range of disabilities to discuss how they go about navigating access barriers. As part of the interview, we discussed several specific AT each participant uses– data related to "AT Acquisition" was preliminarily tagged in our coding process (described in Section 4.3), but not ultimately used in our analysis.

For the current study (i.e., this chapter's study), I reviewed the AT Acquisition data and performed a subsequent round of axial coding, reusing the deductive codebook from *Hard Mode* (Chapter 3) to explore the nine central topics of three Phases (Discovery, Evaluation, Adaptation) crossed with (Resources, Strategies, Challenges).

Given that this data was taken from a study not originally oriented around AT Adoption, it was expected that not all portions of this coding scheme would be adequately represented in the data. To account for this, I conducted a second interview study meant to complement the coverage of this original dataset, with a specific focus on in-depth discussion of specific experiences with AT Adoption.

5.2.2 Secondary Study: Informational Needs & Adoption Process

Our second complementary interview study consisted of semi-structured interviews with a new set of ten participants. An overview of participant disability categories and AT is available in Table 5.1. Participants were directly recruited via the research team's network, using a purposeful recruitment method [117] optimizing for variation among participant experiences with AT.

Similar to the first study, interviews were roughly 60 minutes long and conducted over Zoom,

Table 5.1: Overview of disability identities and sample AT of participants in AT Adoption study. For information on participants in the Models of Disability study (i.e., PA1-PA25), see Section 4.3

PID	Disability Categories	Notable AT
PB1	BVI, Neurological	Prism Glasses, Binaural Beats
PB2	d/Deaf/Hard of Hearing	Hearing Aids, Captioning, Remote ASL Interpreter Services
PB3	Gross Motor, Chronic Illness	examples
PB4	Chronic Illness, Neurodivergence	Medications, Braces, Cane, Grocery Delivery Service
PB5	Neurodivergence, Neurological, BVI	Text-to-Speech Tools, Generative AI / AI-Assisted Programming Tools, Custom Browser Extensions
PB6	Gross Motor	Wheelchair, Manual Car Controls, Power Assist Wheelchair Pusher
PB7	Neurodivergence	Medication, Planning & Accountability Apps
PB8	Gross Motor, Speech, Neurodivergence	AAC, AI-Assisted Programming Tools
PB9	Neurodivergence, Mental Health, Addiction	Noise-Cancelling Headphones, Vitamins & Supplements, Medications
PB10	BVI	Screen Magnification, Phone Camera, ChatGPT
PB11	BVI	Guide Dog, Screen Reader, Headphones

and participants were compensated with a $50 Tango Gift Card for their time. Auto-generated transcripts were then downloaded and reviewed for accuracy of transcription, and any quotes included in this chapter were reviewed against the original recordings for accuracy. These transcripts were then analyzed using the same deductive coding process described in the previous subsection.

5.2.3 Combined Analysis

After completing the initial deductive coding for both studies, I combined the data from the two studies and conducted additional inductive coding on the compiled set, with a particular focus on finding cross-cutting trends spanning participant experiences and multiple phases of the AT Adoption process.[1]

I then concluded this combined analysis by conducting reflexive thematic analysis on the combined data. Following Clarke & Braun's guidelines for reflexive thematic analysis [22], I entered the analysis process with a specific positionality: to identify the everyday labor people with disabilities already perform, with a particular emphasis on informational needs and decision-making.

5.3 Results

5.3.1 Discovery

Resources

Participants described a wide range of specific resources they used for learning about new ATs, but they overwhelmingly fit into three main categories: "expert" resources, peer resources, and searchable online resources.

Expert resources spanned a range of definitions of expertise, from medical professional knowledge to lived expertise from people who faced similar access barriers. A major benefit of these resources was that they often came with some advanced reassurance that they might be likely to succeed in the Evaluation Phase later on, thereby reducing the amount of energy they

[1] Throughout the remainder of this chapter, participants from the original Modeling Accessibility study are denoted "PA", while participants from the second, complementary study are denoted "PB". ID numbers for PA participants are consistent with the ID numbers used in Chapter 4

needed to spend on subsequent Discovery. Similarly, these resources often filtered out ATs that were unlikely to work, further saving energy by reducing failures during Evaluation. However, what qualified as expertise to one person was not necessarily considered expertise to another.

Peer resources, most typically friends, family, and acquaintances, were often desirable for being easy to access and to engage with. In contrast with an expert like an OT, whom participants needed to schedule appointments with, there was a much lower cost to engage with peers, particularly those who were eager to support the person reaching out. Additionally, it was particularly easy to follow-up and have a back-and-forth interaction with peers, which unlocked methods of discovery that were otherwise unavailable. Peer resources also provided the unique opportunity of actively reaching out to the PWD, rather than the PWD needing to take an active role in seeking out AT. Participants described a more passive role of expecting to become informed if there were new ATs that could be useful: *"For people like me– similar culture, similar issue– we compare notes, and we say, you know, "what works for us?" Some things are not well marketed, but I learn through the community, through friends."* (PB2) When Discovery could happen just through ordinary connection with friends, the burden put on the disabled person to search for technology was significantly lessened.

Social media also served as a common resource, with multiple participants citing Twitter, TikTok, Facebook, and Reddit as commonly used platforms for learning about AT. On TikTok, there was a particular emphasis on "the algorithm" and incidentally discovering AT content while scrolling, rather than actively seeking out that content. On Twitter, Facebook, and Reddit, discovery was much more active, falling more in the 'searchable online resources' category.

The final category of searchable online resources had the unique affordance of not requiring interaction with others, which participants described as particularly useful when they undertook wider active searches. Searchable resources took a variety of forms, ranging from archives of conversations on social media platforms, to resources made available by groups such as the Mayo

Clinic or local nonprofits, and to marketplaces and product pages for specific technologies.

When searching social media archives, there were participants discussed having varying degrees of success. Perhaps counterintuitively, participants with less common disabilities sometimes had an easier time finding information online, which they attributed to the communities being more centralized. Subreddits for specific chronic illnesses, for example, were considered easily searchable and often centered around these specific types of access questions.

Naturally, searching marketplaces and store pages came with its own caveats, particularly in that they were often not trusted to contain relevant information that would later be needed for Evaluation. Additionally, some participants considered the role advertising would play in what they actually discovered– there was less confidence that their search would be comprehensive, or surface potential ATs that might be less visible.

Some of the most highly trusted and sought out resources were ones that fell in multiple of these categories. For instance, disabled friends who had been through similar situations were both "experts" and "peers"; and online resources from trusted disability nonprofits were both "expert" and "searchable online" resources.

At the intersection of these three categories live some of the most often relied-upon resources: first-person accounts from people with similar experiences that were shared in easily-searchable online forums, such as subreddits or Facebook groups. A major benefit of these posts were that they often acted as "magnets" for similar accounts, as other community members would often directly reply to the original posts, sharing their own stories and increasing the amount of data gained from a single resource.

There were various benefits described about these collections of stories and comments. One notable benefit was the breadth of expertise encapsulated by the many perspectives shared: particularly for participants with more unique sets of access needs (e.g., those with multiple conditions, or those looking for tools for specific contexts), these resources could lead to discovering

multiple potential technologies to try, often presented with additional context about the differences between each and why people chose to use one or the other.

Strategies

There was a noticeable distinction between "active" and "passive" approaches to Discovery. In active Discovery, a participant would seek out information about AT, often to answer a particular question they had. This might involve asking friends or doctors, researching online, exploring social media, or even brainstorming new AT ideas they could make themselves.

Passive Discovery, on the other hand, was more about having resources that would inform them when there was something relevant for them to know about. For some, this was done by developing strong-knit communities of people with similar access needs, which came with the added benefit of filtering out noise: *"I get my information for accessible technology from the [Deaf] community, definitely... there are so many different people, and they have their own preferences, too... it lessens The time that it takes me to become educated on something, because they are going to tell me exactly how it's going to serve me, versus getting into the minutiae of the details [like an ad would]. So it saves my energy, it saves my time. They have already filtered it, so to speak, to my needs."* (PB2)

Additional passive Discovery happened on social media, and was sometimes influenced by following particular disabled content creators. However, some also attributed their success to "the algorithm", rather than their own intentional manipulation of their feed. PB5, for instance, would sometimes encounter AT information on LinkedIn, which they then leveraged to increase the likelihood of seeing more content in the future: *"it's the algorithm, it will show me, like, a random connection or something. So it'll always be, like, random strangers, that I don't know, but sometimes if I really like their tip, I will go and follow them or send them a connect if we have enough mutuals in our network."*

Many participants described engaging in both active and passive Discovery. When PB1 was

first beginning her journey with disability, she gradually transitioned from passive Discovery into more active modes: *"for a long time, it was pretty passive, and I had some discomfort with, you know, just kind of taking what the algorithm has gifted me over the day. But, I think over time, once I kind of had the right vocabulary and the kinds of things I was looking for, there was more intentionality... It's becoming less algorithmic-based, for sure, but both have been pretty equally important."*

Some participants who had not significantly changed their repertoire in many years were still excited to learn about new AT, even if they had no interest in adopting anything new. Given the highly social nature of AT Adoption, knowledge of various devices was a valuable resource to be able to share with others. *"I have to decide if I want to spend the time and the energy to really analyze the technology or the equipment. And then if I like it, I'll be that person that brings it back to my community and share that information. That's also a responsibility of mine. That reciprocity."* (PB2)

Participants also discussed wanting to familiarize themselves with the current state of AT beyond the devices they use personally. *"You know people who have different problems than you... I'm gonna make mental notes. Unless I know somebody already who could use the device– then I make harder mental notes."* (PB6)

Challenges

A common challenge was not knowing where to look for information when engaging in active search. *"That's the unfortunate part with a lot of this accessible technology. You can't just go to a sporting goods store and play with it, you know? So that's the biggest con, I think. If we had more... Like, there's some health shops that have stuff, but it's more like the transport chairs and the walkers, and not, like, the tens of thousands of dollars worth of equipment."* (PB3)

When relying on others for Discovery, some participants expressed uncertainty of whether the suggested tool would even be worth their time. PB9, for instance, was skeptical when their

mother ordered dietary supplements to manage their cognitive symptoms (*"jury's out on whether or not they work... she's big on, like, nutrients and vitamins and stuff or me"*), and PB4 was uncertain about the credibility of "strangers on the internet": *"I mean, I very much take the content there with a grain of salt, because it's just a bunch of people saying stuff, with no assurance to me that it would be relevant to me. I mean, I think that everyone there has a credential in the sense that if they have the disease, it's their business to talk about their experience... A lot of times what I'm really looking for is some kind of either reassurance or new idea for something to try."*

Additionally, not all participants had success turning to medical experts for Discovery. PB4 said she often felt she needed to suggest potential solutions to her doctors, rather than having the doctors suggest the solutions to her (*"I joke that I'm my own primary care doctor"*). Though PB5 often turned to doctors and OTs for AT suggestions, they found that sometimes solutions were just not appropriately tailored to their specific condition: *"they have the same curriculum that they use for people with, like, chronic fatigue syndrome, MS, and Lyme, and it's, like, this very uniform binder curriculum thing. I haven't seen as much, flexibility on that... I don't think I've found a single OT or doctor that can help me manage fatigue in a way that I would find enjoyable or preferable."*

There were also challenges in deciding how often to actually look for new AT (i.e., when to begin a new Discovery process). This sometimes coincided with people first learning about their disability: PB1, who had a neurological vision condition since birth, did not realize she had this condition until she learned about a particular AT (prism lenses) on social media– prior to this discovery, she had not considered looking for specific AT for a condition she did not know she had.

5.3.2 Evaluation

Resources

Once again, social resources were frequently used, with some participants effectively combining Discovery and Evaluation into a simultaneous process with a particular social connection. In cases where there were many different possible AT options, it was considered particularly helpful when a connection could recommend a place to start Evaluation: *"I have a family friend who has [the same condition], and I had actually been looking into this low histamine diet, because people talk about that being helpful... And so I was like, oh, do you have any advice for that? And then she was like, '[a particular medication] is the only thing that I attribute being a major helper.' Like, basically, she didn't even endorse the idea of doing, diet-related changes, and was just like, '[the medication] is [what makes] the night and day difference for me,' ... then I go to my doctor, and I say, hey, can we try [it]?"* (PB4).

Doctors and AT professionals were sometimes consulted for their assessment of a particular kind of AT. PB5, for instance, regularly asked their doctors and OTs for a *"seal of approval"* on devices and hacks they were considering using. In some cases, working with a doctor could enable Evaluation of multiple "versions" of a tool. PB9 actively worked with their psychiatrist to experiment with different levels of ADHD medications, in part to find dosages to adjust to when life situations changed. *"I brought up with my [psychiatrist] that sometimes when I have like a lot going on a certain day, I'll take two pills instead... he's like, 'well, maybe that means we should have you on a double dosage' ... And I did that for a couple months... [but] I was kind of burning myself out... and so I had a conversation, like, I want to go back down... Just being able to have these conversations, and frankly, having [a psychiatrist] who is so open to changing dosages as life changes has been incredible."*

Once again, some participants turned to online disability communities to collect information

to inform their evaluations. Since these resources were also commonly used for Discovery, little additional searching was required when transitioning into Evaluation, often resulting in these accounts being some of the first resources used for Evaluation. However, participants described once again needing to evaluate other people's accounts to determine if they were even helpful or relevant to their own evaluation.

PB1 described learning how to filter what content was most likely to be relevant: *"It depends on how much, I immediately [resonate] with the information. Like, if somebody was talking about 'I didn't realize how chronically overstimulated I was till I tried it,' I might buy something immediately."* However, absent these clues, she needed to do further research to complete her evaluation: *"I might also ask around...my disability community... [or] leave the [browser] tab open and forget about it, and then find it again in 6 months. And I've had a number of accessibility tools where I've had to be like, 'okay, we'll get you next round'...it's overwhelming to really try to deal with [all the information] all at once."*

When all else failed, the ability to acquire the AT and try it first-hand was particularly valuable, but this was not always an available option. PB3 discussed how the online discount market Temu was occasionally a useful tool: *"there's accessible tools, not as much technology, on Temu, and I've tried some of, like, the sock helpers for compression socks. Some of it, if it's cheap, it's like, 'okay, I can take the risk', but if it's, like. a big investment, I go [elsewhere]... I think a lot of it just depends on, like, the cost and things like that."*

Strategies

The most notable factor affecting strategies for Evaluation was what particular types of information participants sought out.

When consulting social resources, participants often specifically sought out personal accounts, rather than just looking for a person's judgment or evaluation. *"In terms of evaluating what other*

people have written, what I'm really looking for is just personal accounts. I don't usually, on the basis of something someone has written, like, go out, buy a supplement, and try it. But it does inform what I talk to my doctors about... To be honest, I actually use it more to verify what my doctors say than it is for me to prepare. Like, if my doctor says, 'okay, try this, this, and this.' I'll search those things into the subreddit and see how people experienced it." (PB4)

When investigating a particular product, there was a wide variety of specific attributes participants sought out. Though far from a comprehensive list, these attributes included price, material, physical dimensions, weight, where it can be purchased, whether it would be covered by insurance, where it was manufactured, the manufacturer/distributor's reputation, and the process for getting it repaired.

One other major difference in strategies across participants involved how frequently they decided to engage in Evaluation. In particular, some participants described a reluctance to look for new AT until the current solutions they had actively stopped working. *"Of course, new technology is usually a little more expensive than maybe what you're using. And then there's the stubborn factor of 'I'm already comfortable with this. Why do I want to learn something new?' Cassette tapes were certainly one [AT] I held on to forever. They're cheap [and] dedicated. It always worked."* (PA16)

Others cited the difficulty of trying to "keep up" with an ever-changing AT landscape: *"I haven't gotten that far in like a solution. By the time I do they'll be telling me it's time to the technology advance, and it's time for an assessment for a new one. Because and it's a long process to get one. And then by the time you get one day once that we. We keep one for about 3 years."* (PA21)

However, some participants were eager to try a variety of options, hoping to find the best match for a particular setting. PA1, who had highly fluctuating access needs depending on their chronic illness and changes in their environment, prided herself on her skill in trying a range of AT: *"as I've had more experience with this, [I've] just sort of gotten more comfortable changing up how I'm doing things based on what my needs are, and on any given day or month. I've gotten more*

confident in just trying out new tools or gear, or asking for different prescriptions as necessary just to just sort of try them on for size."

Challenges

The most commonly discussed challenge was the costs (financial or otherwise) required to confidently complete an evaluation of a potential solution, with no guarantee of a "successful" evaluation (i.e., ending up with a new tool to use).

In particular, there were many instances discussed where participants would need to purchase a piece of AT and try using it before they could be confident it would work for them. However, free options for trying AT (such as lending libraries) were sometimes insufficient: *"[I'm always cautious] to try new AT because of... financial accessibility, specifically. Like we have an at lending library type of program here... but it's often not robust. And even so, it's not necessarily going to have the tools that I was looking for."* (PA11) Similarly, relying on medical resources for support could get exceedingly expensive, especially when the expenses weren't covered by insurance. *"There's other hurdles in all of these medications. Like, [this one medication] is not FDA approved because there's not enough demand for it, because this is not a common complaint. And so you have to get it from a compounding pharmacy, and you can't get insurance to cover it. And so, like, doctors will try the things that are more accessible first."* (PB4)

Another prominent challenge involved determining what criteria were most relevant for evaluation. This was further complicated when criteria for evaluation would change over time or across contexts. Depending on evolving life situations, sometimes a tool that was considered a poor fit would later become a good fit– but knowing to return to a rejected device and reevaluate it was not always easy. PA8, for instance, described significant differences between how their parents evaluated AT when they were a child and their own evaluations as a young, newly independent adult: *"because of their [immigrant] experience they were very adamant about trying to save money,*

which would mean... they would not really seek out a lot of medical care that they could have and I think that really kind of indirectly impacted [my] willingness or comfort with getting assistive technologies... I don't think I was really presented as a kid, as having that right or autonomy to talk to doctors myself, so it just [recently] occurred to me like, 'oh, I have these health issues. Maybe I should bring them up, and they could suggest something to improve my quality of life."'

When relying on others for evaluation, there was once again a question of accuracy and transferability of someone else's assesment. On social media, this was further exacerbated by the potential of biased, sponsored content that did not actually reflect a content creator's true stance: *"[for] some of these big creators, it could be a brand deal, and then you kind of have to think, like, 'okay, do they really believe in the product?' But, like, showing how it's used and stuff like that, that can really sell me, and I'm just like, 'hey, you know, get paid!' Like, it's all good."* (PB3). However, some participants learned to recognize this type of content and adjusted their expectations accordingly: " *[a video about] a technology piece is more, like, show and tell."* (PB3).

In some cases, it was also difficult to be confident that an Evaluation was actually complete or correct. In the case of psychoactive medications (such as those for ADHD, depression and anxiety), it was difficult to actually gather "data" necessary for Evaluation. *"[I had to go on] the 'pill journey' where you like, try a new medication, then you have to like, wait a month to see if it works, and then if it doesn't work, you have to wean off of the medication and get on the next one... And it takes a really long time to figure out what's what for your anatomy"* (PA12). In addition to being time-consuming, this process could also be traumatizing in its own right: *"You're just constantly on this flow of emotional roller coasters"* (PA12).

The experience was similar when balancing side effects of medications and treatments for chronic illness symptoms: *"It's tough, and it varies medication to medication, because they have different effects in the body. For [one medication], it actually took me a couple weeks to realize just how miserable it was making me. The main issue with [the medication] is it can cause, like, major,*

mental health side effects, including, like, depression and suicide. And it has, like, a black box warning for that when you try and buy it [even though] it's an asthma medication... I was like, okay, I feel like I'm too miserable... I was like, okay, this is probably the medication, which was really upsetting, because the medication was the was helping, right? And so I stopped it, and it took weeks to feel back to normal again" (PB4). However, gaining experience through these failed evaluations sometimes benefitted future evaluations: *"I tried the, replacement [medication], which is a slightly different drug, but it operates in the same mechanism. And I took one dose, and immediately it was, like, crying over everything. Like, I was so down, and I was like, yeah, no, that must be the medication. I stopped it, but it took, again, days to feel back to normal"* (PB4).

5.3.3 Adaptation

Resources

OTs and PTs were sometimes the first resources consulted for Adaptation, with some participants describing how their OTs would propose adaptations before they had even tried the tool. *"[My OTs and PTs] have given me so many suggestions... and every time they bring it up I'm like 'Oh, that's a good idea. I don't know why I didn't think of that myself,' but ... when I was discharged from the hospital, it was just kind of like, 'okay, bye!' ... But at that time I had only worked my body up to being able to be in the wheelchair maybe an hour a day, because your body has to get used to it, and I didn't know what I didn't know, and I didn't know who to ask."* (PA6)

Participants who had preexisting experience with DIY and fabrication leveraged these resources for Adaptation. PB6 was able to customize his wheelchair through his connection to a metalworker who he could commission for custom aluminum parts. Similarly, PA10 produced custom AT using 3D printers to address limitations of the tools he had previously bought, while PB9 3D printed tools they found on Thingiverse to improve the accessibility usability of non-AT devices they

already had.

Adaptation was generally less social than other phases, but some participants still relied on others for support in the process. In particular, the community surrounding the culture of "life hacks" and access hacking [62] was viewed as a potential resource for Adaptations participants had not previously considered. However, these were described primarily as passive resources, where people would incidentally happen to learn about a hack by scrolling on social media, rather than actively seeking out information in these communities.

Coming up with 'hacky' solutions was sometimes aided by social connections: PB9 described turning to their trusted friends and family to help come up with solutions to an issue when they were having a particularly tough time, and PB5 discussed how to use certain everyday tools in clever ways to address niche access needs (e.g., using blue painter's tape to create consistent organization boundaries that accommodated their ADHD).

Strategies

Participants varied in how frequently they intended to adapt AT, with some expecting to be able to use AT straight out of the box, and others expecting to need to modify their AT either right away or later on down the line. For some, adaptation was a last resort, and they would much rather find a new AT that would better suit them than work to modify an imperfect one. However, many participants expected there would be an adjustment period when using new AT, both in adapting their own behaviors and usage of it as well as potentially modifying the tool itself.

For individuals with well-known, highly-researched disabilities (e.g., some BVI and DHH participants who had fairly common diagnoses and access needs), Adaptation was primarily considered to be the responsibility of the individual to adapt to the technology as-is. For instance, PB2, who is Deaf, was definitive about which technologies she could or could not use, and PB11 considered himself a "creature of habit" who would not change the particular tools he used. Instead,

PB11, who had had several different guide dogs over the years, described that there was always an adjustment period in which he learned how the new dog preferred to navigate, and figured out how to adapt in that direction.

Adaptation strategies also included choices to begin using AT in a new context or in a different way. For instance, P4 described starting to bring a cane with her to the airport as a *"disability signifier"* to navigate unexpected socially-created access barriers: *"A cane doesn't actually, provide me increased mobility, it signifies disability, and that's what I use it for... It really helps me to board when no one's on the plane... but I look like a young woman who, has no sort of apparent obvious signs of a disability, and so I've had a couple times where I've gone up to board, and they, like, stop me, or they look at me funny... And so I have this cane that, like, folds up, and I keep it in my bag, and as I'm navigating the airport, I'm not using it, I'm walking around. And then as soon as I get to the gate, I take it out, and then I just hold it as I board the plane, and then they just… they see it, and they let me board."*

Despite P4's initial determination that a cane didn't help her, using a cane in a different manner actually *was* helpful for managing symptoms– but rather than using it for physical support, she could employ it to gain access to disability resources that reduced the amount of painful activities (i.e., spending extended periods standing in line), thereby reducing her total amount of pain.

Challenges

For participants who created their own "DIY" adaptations, it was sometimes an elaborate, iterative process to develop a modification. PB6 described being on *"generation four"* of custom cupholders for his wheelchair, having tried a mix of commercially available tools, 3D printed parts, and manually hacked the pieces together.

Similarly, some individuals with complex diagnoses (e.g., people with multiple disabilities/conditions, or those with fluctuating access needs) expressed that the process of Adaptation "never ended".

PB9, whose mental health conditions manifested differently depending on life circumstances, discussed how they would adjust their medications to account for this: *"I try to deal with 'I don't have enough energy' by adding more Ritalin. And then I have enough energy, but I'm burning myself out, so I go back down, and so it's like– there's never a stable state. It's whack-a-mole, right? It's always a constant game of checking in and checking in: 'How are we doing right now?"'* Ultimately, being able to vary the dosage was considered beneficial, but required regular reflection and accepting the possibility routines may change.

5.3.4 Additional Themes

The Complexity of Trust

When considering various information sources in their adoption processes, participants developed their own systems for determining how much they trust the recommendations of a source.

For information considered subjective (e.g., the advice of a friend, a post from someone on the internet, or sometimes the suggestions of a medical professional), participants often interpreted the information based on their perception of the source's credibility. They generally had three (unspoken) categories of these sources: people whose judgment is reliable, people who provide data for further analysis, and people whose opinions are to be disregarded.

These judgments were made based on a variety of factors, including the participant's social relationship and familiarity with the source, whether the participant had previously taken their suggestions, and how these suggestions were regarded by others.

For sources a participant had a close, personal connection with, there was often an expressed confidence that the source knew their needs well enough to make an effective decision. *"If it comes from a friend who knows me well, I will almost always take that at face value and be like, 'okay, cool, I will find a way to try and demo that somehow.' ... So I think those recommendations from the friend*

are the ones that, I will sort of trust, because if they've been around with me enough, they know what my issues are, they've seen my issues" (PB5). However, sometimes social relationships complicated a participant's ability to dismiss a potential option. PB9, who expressed vocal skepticism about the efficacy of vitamins and supplements for their access needs, felt a pressure to try them because a parent had given them some. *"[My parent] insists it's good, and... I don't know. I have options. It also is now the situation where I'm kind of overwhelmed by how many things I'm expected to try, so I'm, like, kind of not really trying any of them. That's its own thing."*

For people participants were less close with, particularly those they met online via social media, there were various ways of assessing the credibility. *"If I've been following the person, that helps build the trust. If it's just, like, an ad that maybe is targeted towards me, I don't rule it out... it kind of is like, [asking myself] 'is this for me?"'* (PB3). When PB5 found access hacks (particularly involving AI) on LinkedIn, they were often able to gather additional context about the poster's credibility by looking for certain information on their profile: *"It's a little bit shallow, but if I see a post from somebody who's, like, a staff engineer at Google, and they said that this works for them, I'm gonna assume that they are probably highly technical, they know what they're doing– I'm gonna try it. ... Like, if it is being posted by principals or architects, ... usually people that have many years a software experience, even prior to AI, so I'm more likely to take the word of those folks who are posting those hacks. Also people within accessibility community, like posts from blind devs, I'm like, 'okay, I take your word for it, I'm gonna go and try that, too, because I assume you know.' When people are using it for their access needs, they don't want to mess around. They want it to be solid."*

There were also varying stances on the credibility of medical professionals and others considered "experts". PB3 specifically separated her doctor's expertise in her conditions from perceived expertise in AT: *"I've been going to neuromuscular specialists for, like, 30 years, and... they didn't harp on [getting me AT], but like, 'oh, if [your condition] ever progresses, then we can discuss a mobility aid of whatever sort.' And then it was more talking about [unrelated topics]. That was when*

it came up, but it was more [because I brought] it up. For the first time [recently] they did bring up a technology. It wasn't going to be a good fit for me, but it was interesting that it may be more of a conversation in the future where they're telling me about a product, you know, because that was new."

PB4 wanted to discuss solutions with her doctors, but she often felt she needed to suggest potential solutions to her doctors, rather than having the doctors suggest the solutions to her. She attributed much of this dynamic to the complexity of knowing about specific chronic illnesses: *"knowledge about hypermobility and [my specific diagnosis] explains a lot, but because it's so under-researched, it's really hard to find a provider who knows anything about it and can give you any useful information. These days, I get a lot of my ideas of things to try from subreddits... people will say, 'oh, I tried this', and then I'll go to my allergy doctor and say, 'what about that?' And they're like, 'okay', and they prescribe it to me."*

When credibility couldn't be verified, participants still sometimes considered the poster's suggestion, but sought out additional verification before making a decision. Multiple participants emphasized the need to "take things with a grain of salt" when reading internet comments, and relied more on higher-level trends across posts than any single specific comment. *"Usually what it starts as is: I search a symptom. And then I'll see what people say in relation to that symptom. Other times, I'll search, like– maybe my doctor suggested a medication. I'll search that medication and see other people's experiences of the medication... what I'm really looking for is just personal accounts"* (PB4). Alternatively, some participants would bring the unverified information they found to a more trustworthy source: *"It depends how much I immediately feel, like, resonance with the information. Like, if somebody was talking about 'I didn't realize how chronically overstimulated I was till I tried this!' I might buy something immediately. Or I might also ask around, now that I have disabled community."* (PB1)

However, criteria for dismissal were also useful in expediting the process. When looking for comments about AT on Reddit, PB4 specifically sought out *"people who seem to be dealing with*

the same thing as me advocating for it. So not just people advocating for it, but people who are dealing with specifically what I'm dealing with, right? Because, like, a lot of times I'll read Reddit comments where it's like, 'well, I have MS, and I do blah blah blah,' and it's like, well, I don't? So I don't necessarily think that that is, gonna help me, even if it helps them. So I would want to see that someone has [the same conditions as me]." PB5 often dismissed posts that seemed "performative": *"Some guy would be like, 'oh yeah, I just used generative AI and tried out this new whatever to code a video game from scratch.' That's very cool, and then they kind of go on with their life. Whereas ... if I learn about somebody who's using generative AI for daily work, that makes me think, 'hey, they're going to be using it for things that aren't just demos, they're probably using it to ... do this sort of more grindy, daily work... I'm always more drawn to the stories of people using things for their, daily, less glamorous tasks... the sustainability of the daily uses is very important to me."*

Who (Actually) Wants to Adopt an AT?

There was also ample discussion across participants about high-level decision-making around whether or not to look for or try out a new AT.

Once a person had become comfortable with a particular AT, it was seldom abandoned outright, unless it broke or was replaced with a newer version. Upgrading AT was sometimes considered appealing, but if the upgrade would require investing more energy and resources, there were significant trade-offs to weigh. When PB6 discovered a new carbon fiber wheelchair, he didn't decide to upgrade until a specific opportunity presented itself: *"I felt it and said, boy, this is light. Wouldn't it be nice to have one? And, A year or two later. I was at a picnic with the distributor. And I said, gosh, if you ever find one of these that you're trying to get rid of– Because I knew how much it cost– give me a buzz. And A year or so after that, he gave me a buzz and said, the Swedish company is abandoning the North American market, and I've got one that I'll sell you for cheap."*

For some, finding a new technology to use was generally appealing, due to a person's own

disposition towards technology adoption. *"I've always been the one to try and find a solution to figure it out, and if solutions are finding accessibility for people, then that's just who I am. It's always been part of me."* (PA4) For participants who had more recently acquired disabilities or who were still in the process of learning about their access needs and disability identity, there was also an understanding that Adoption would be ongoing for a period of time, and that was simply a required energy expenditure for the time being.

For others, needing to adopt a new technology was viewed as more of a burden, and might only be done if absolutely necessary. For PA16, this was a complicated topic: *"Part of it is the economics of it: how much is the new tool gonna cost? And there's the learning how to use it– And I know some people love anytime they get their hands on a new gadget– it's just such a thrill, and they can't wait to learn how to use it. That's not me. I like some things, but I don't need to learn everything about the new gadget, and usually they tend to have more features than I care to learn and want to worry about."* However, when his prior technologies stopped being manufactured, he considered himself "grateful" for the change: *"I think a lot of the migration was good ultimately, and I don't certainly don't buck at it. But transition is is hard like, I said, for the the expense, the training, the leaving your comfort zone."*

The situation was further complicated when determining *when* to actively look for new AT. The process of searching for and evaluating AT can take quite a bit of effort, and participants described making judgment calls around whether the search would be worthwhile. For participants who employed passive modes of Discovery, they would sometimes be introduced to a new technology at an arbitrary time and forced to decide if they currently had the bandwidth to explore it. PB1 relied on storing browser tabs on her computer that had links to AT she had previously discovered but not yet investigated. *"I'm trying to let it be a more intuitive process... If my [intuition] says it's not time to deal with the tab, it's not time to deal with the tab, and I just don't deal with it. There are times when, you know, my computer crashes, and I lose all my tabs, and that's, like, a very*

disorienting experience, but I've just tried to trust, like, well, maybe I didn't need that, and it'll come back when I need it again."

However, even if their searches did not necessarily surface information useful for themselves, some participants found ways to use whatever information they uncovered, which may have reduced some of the "risk" associated with investing energy in looking for new AT. Practically, a "failed" search (i.e., one that did not result in a lasting solution) still produced valuable insight.

5.4 Discussion

5.4.1 What's So Special about *Access* Technology Adoption?

In considering the experience of AT adoption for PWD, it is important to investigate whether there is anything particularly unique to the space of AT adoption that is not also seen in general technology adoption for PWD.

Having used a near-identical approach to analyzing game adoption by PWD in *Hard Mode* [105], we can directly compare differences between game adoption and AT adoption, which can serve as a starting place for answering this question.

Across all phases of adoption, there were some notable differences in what resources were consulted. In particular, resources were generally much more spread out in AT adoption than in game adoption. In both studies, participants expressed a specific frustration with there being a centralized "store" they could explore: in *Hard Mode*, this was regarding the task of browsing accessible games during Discovery, while in this study, it was surfaced in the context of wanting to be able to test specific AT out during Evaluation. However, in both studies, this decentralization of resources was pointed to as a key shortcoming. However, comparatively, games have a much more centralized search space– although there is little guidance on where to search for *accessible*

	Phase	AT Adoption	Game Adoption
Discovery	Resources	Social, Expert, Online Search	Social, Online Communities, Game Stores
	Strategies	Active Search: Consulting experts, Searching online stores, Engaging online communities Passive Search: Talking to friends, scrolling social media	Passive scrolling on social media, Asking friends or hearing from them, Browsing game stores
	Challenges	Not knowing where to look, Skepticism of whether something is worth trying	Tradeoff between access needs and personal taste, Inaccessibility of game stores
Evaluation	Resources	Advice from peers, Assessments from experts, Searching online communities	Advice from peers, Community-built platforms/resources, Preexisting contextual knowledge
	Strategies	Comparing personal accounts, Consulting experts, Identifying relevant attributes, Trying first-hand	Comparing accessibility reviews, Identifying accessibility features, Reviewing official and community-generated media (trailers, gameplay videos, etc.)
	Challenges	Financial/Energy investment on failed evaluation, Uncertainty of assessment, Difficulty in completing assessment	Financial/Energy investment on a failed evaluation, Uncertainty of assessment, Difficulty finding needed information
Adaptation	Resources	Experts, DIY hacking & fabrication, Content from "hacker" communities	DIY hacking & fabrication, Online gaming subcommunities
	Strategies	Modifying tools, Using tools in new ways, Abandonment	Modifying games, Modifying gaming setup/context, Changing playstyle, Abandonment
	Challenges	Financial/Energy investment, Need for ongoing iteration, Risk of potential failure in certain contexts	Financial/Energy investment, Need to adjust expectations of engagement

Table 5.2: Comparison of participant experiences with AT Adoption vs. experiences with game adoption (taken from Chapter 3 and [105])

games, there is at least a small number of (digital) game stores to search (e.g., Steam, Epic, and console-specific stores). In contrast, there is a staggeringly broad set of places to look for AT– participants were exploring large swaths of the internet hunting down AT they could adopt, and many tools could only be acquired with external assistance (e.g., through doctors or OTs).

The consideration of adoption cost (both in terms of finances and energy) was also prominent in both studies, but there were again key differences. In the space of games, there was a fairly constrained range of costs, with most games costing no more than $70. AT, on the other hand, could potentially cost thousands of dollars, while some lighter weight access hacks could cost magnitudes less. This was further complicated by insurance's role in AT adoption: in some cases, the effective financial cost of AT would not actually be known unless a person went through the process of checking with their insurance, which of course could be a fairly significant task.

In terms of energy investment, the most extreme difference between the two cases was during Evaluation, particularly when participants needed to try the tech out first-hand for their evaluation. Games, no matter how inaccessible, seldom put the player in active danger or had lasting consequences to the player's bodymind. However, depending what AT was being tested, PWD might have to navigate side effects of medication, physical discomfort from a new worn device, or even the risk of being in an actively dangerous scenario (e.g., PB6's concern with a wheelchair breaking while out traveling).

One final difference was how participants adjusted in their assessments of technology and its accessibility over time. In Adaptation for games, one of the main patterns we identified was "iterative adaptation": a player would start a game that had a certain level of inaccessibility, and over time, they would find ways to make the game more accessible to them. Relatedly, we found that participants had a less (universally) rigid expectation of a game's accessibility up-front, and did not expect that their initial Evaluation would necessarily hold as the game evolved over time. In contrast, there was significant weight put on the accuracy of assessments of AT, and

with good reason. As previously mentioned, an incorrectly selected AT could cause significant problems for the person trying it out– there were much steeper consequences for discovering that an Evaluation did not hold in all contexts, so the required level of confidence needed for Evaluation was considerably higher for AT than for games.

Underlying many of these differences is the fundamental fact that AT is, in the vast majority of cases, more important to a person than a game is. However, comparing AT to technology at large, there are a unique set of considerations for AT that we can see specifically influence its adoption.

For instance, consider the consequences of AT failure: the set of technologies that risk causing active physical harm to a user when they fail is quite a narrow, specific set, and many of them– such as cars and appliances– have entire ecosystems surrounding their adoption, matching people with the right technology, extensive documentation of the tool's safety, and so on.

Adopting AT is also such a highly personalized process that many existing systems related to adopting technology– such as customer ratings and reviews, recommendations on ecommerce sites, or in-person browsing in stores and showrooms– does not effectively map onto the process of adopting AT.

As we consider how to better support PWD in AT Adoption, it is crucial that we not simply default to existing design patterns for technology adoption, as AT Adoption has key differences that render these processes ineffective or, worse, actively harmful.

5.4.2 Design Takeaways

Trust Can't Be Faked.

Throughout all stages of AT Adoption, we saw participants express reasonable skepticism about whether or not they could trust a particular recommendation or piece of information. Even when distributors used ads and sponsored content on social media, there was such a well-established

process of verifying information, cross-referencing with others, and doing additional research that unreliable information seldom actually translated to Adoption. This speaks to some of how AT marketing and distribution needs to differ from other commercial technology marketing: in lieu of flashy advertising, manufacturers and distributors ought to emphasize transparency of data connect interested PWD to known, trusted sources.

"Off-Label" AT Usage.

Particularly considering how participants adapt AT, we can see how off-the-shelf AT is sometimes just a starting point for a user, and AT designers ought to keep this in mind. Similar to Mack et al.'s recommendation to consider AT's role in a repertoire [101], designers might also consider how PWD might want to adapt AT and explicitly account for this in their designs. Various research projects have explored custom modifications for AT (e.g., [28]), and beyond simply listing possible modifications, designers might also provide more detailed information about the device itself to enable custom hacking, or even consider making their codebase open-source to invite the community to create new modifications.

One Size Fits Some (And That's Fine!).

Participants were candid about how some ATs just aren't the right fit for them, but there was rarely any fault put on the designers or manufacturers– it was generally understood that that tool might still work for someone else. As opposed to generalist approaches to technology that strive for a 'one size fits all' design, it is much more valuable to be clear about who a particular design is for and what it specifically does. Being able to confidently conclude that a tool was *not* a good fit for them during Evaluation was useful for their overall adoption process, and so allowing PWD to more easily decide identify mismatch is advantageous in the bigger picture.

Visibility & Discovery is a Group Effort.

The process of adopting AT is a communal, collaborative effort, and many participants emphasized the key role trusted friends play in their adoption process. Some took an active role as AT experts,

and sought to learn about new AT regardless of its relevance to them so they could later suggest it to friends. Given this context, AT designers and distributors should consider broader approaches to publicizing their tools that consider more than just their target users.

5.5 Coda: Strategizing in a Multiplayer Game of Accessibility

5.5.1 Community-Built Resources: Theorycrafting & the "Meta"

A central finding of this work concerns just how social of a process AT adoption is, with social resources considered integral through all stages of AT adoption. Within this, a particularly valuable form of social resource was online first-person accounts, where disabled individuals shared their own experiences with a tool in a way that supported others in their own evaluations. In contrast to other forms of consumer reviews, these accounts often centered the disabled author's personal disability identity, which was considered valuable for assessing what parts, if any, of the author's perspective are relevant. This surfaces an interesting consideration for the game of accessibility: a person's ability to succeed in the game is affected not just by *interacting* with others, but by understanding how others experience the game themselves. In essence, the game is a multiplayer game that also involves active collaboration with other players related to strategizing and the development of shared resources.

This is consistent with other findings related to disabled gaming communities. Ringland et al.'s exploration of autistic *Minecraft* communities (i.e., [130, 132]) demonstrated how creating accessible, inclusive gaming spaces sometimes required a joint effort of a larger disabled community to carve out a niche. And similarly, our findings have emphasized just how much disabled individuals rely on the work others have done to navigate the complex, inaccessible systems in place for adopting AT. Notably, a central recommendation of this work is that there ought to be

more centralized resources for disabled individuals to share their personal experiences and lessons they learned during the AT adoption process, with a goal of making it easier for others to review this information and approach the process without needing to redo work others have already done. This is conceptually similar to common practices in gaming communities, particularly in the space of online or multiplayer games, where players collaborate to analyze certain game choices to compare, rank, and differentiate what choices are best for different players.

One common version of this gaming practice is known as the development of a "meta" (which is related to but meaningfully different from the premise of "metagaming", which we discussed in Section 2.4.4). A meta is, effectively, a community-developed framework that analyzes how varying player choices (commonly in a game that has a large-but-finite number of choices) interact or match up with each other, often with a goal of helping players adopt effective strategies or develop new strategies to counter existing ones. For instance, in games with "seasonal" content (i.e., games with significant updates on a regular basis that introduce new choices and mechanics), an established meta can support players in determining what choices to make that align with their preferences, without requiring that they spend significant energy up front learning the new mechanics and strategizing around them. Similarly, games with active online competitive multiplayer communities might benefit from sharing metas that describe common player strategies so new players can more easily compete with seasoned players, or so seasoned players can experiment with new strategies that can upend the existing meta.

Central to this model is the concept of players analyzing the current set of mechanics of a game, as well as understanding how other players experience the mechanics. By understanding how players engage with mechanics, innovators in the community can identify common strengths of certain strategies, as well as vulnerabilities and limitations of these strategies. Through collective analysis of the existing mechanics, the community shares and distributes the task of calculating how to succeed in the game's current set of challenges, enabling each individual player to take

advantage of this analysis without requiring each player to undertake an unreasonably large task. A common practice in this analysis is called "theorycrafting" [119], where players analyze interactions between game mechanics in the abstract, in a way that can surface unique synergies (or frictions) between mechanics that may merit further investigation and experimentation.

For instance, suppose the multiplayer shooter game *Overwatch* introduces a new hero (i.e., character a player can play as) named Absorbo, with a special "absorption shield" ability that lets them absorb any damage that was dealt to a teammate. However, to keep this character from being "over-powered", the developers gave the character little ability to deal damage themselves. Theorycrafting around this new character might consider questions such as:

- What heroes benefit most from being protected by the absorption shield? Are there new ways these heroes can be employed along with Absorbo to unlock new synergistic strategies?
- What heroes are most effective at mitigating Absorbo's shield? How do these heroes perform against the heroes who synergize with Absorbo?
- How difficult is it to play Absorbo effectively? Does a player need to have a particular skill (e.g., fast reflexes) to succeed on a team as Absorbo? Could this be a good hero for inexperienced players?

We can apply this same approach to the Game of Accessibility. For instance, suppose a new AT is introduced for people with foot/ankle joint pain that removes pressure from a person's foot when walking, instead relocating the pressure to their upper leg and knee. "Theorycrafting" around this technology might ask:

- What disabilities can benefit from this AT? Is it only useful for people who experience joint pain when walking (the AT's intended audience), or could it be used by others (e.g., people with lower body limb differences)?

- What scenarios is this AT not actually useful in? Does the AT still work when, say, exercising or doing physical therapy?
- Does this AT require a person to have experience using other tools as well, or does it stand alone? Is it accessible to all audiences (e.g., financially, medically)?

After initial theorycrafting, there can then be broader efforts from the community to experiment and evaluate these theories, eventually incorporating these findings into the current AT "meta". This meta could then support newly disabled individuals in identifying what AT is right for them, or aid people who may otherwise seek to change or expand their AT repertoire.

5.5.2 Metagaming, Strategy, and Varying Goals

A major reason metas and other community resources exist in gaming is to support players in determining what playstyle choices best suit their individual preferences– if everyone agreed on a single "best" choice, there would be little need for analytical resources. This premise is consistent with what we have seen in AT adoption: there is no single "best" tool (or repertoire) for a certain disability or access barrier; instead, we know different people have different goals, motivating the adoption of different tools.

Given this, we can also consider how varying AT can relate to distinct gameplay strategies in the game of accessibility. Revisiting the concepts of metagaming and identity-based gaming (see Section 2.4.4), we can develop a model of what metagames are most common or desirable, and how these games uniquely differ from the "default" set of rules around how the game is expected to be played. For instance, consider the metagame of the early adopter who aims to learn about a wide range of AT and share information with their community. The "rules" of their game puts additional weight on the task of learning about technology, and perhaps finding a particular AT does not work for them is not considered a "loss". Contrast this with the metagame

of a low-income disabled young adult who has recently moved to a new city where they do not yet have a support network. Their metagame might prioritize finding AT that is easily attainable, has a large online user community, and is affordable to acquire and/or repair. For them, trying an AT and finding it does not work for them is genuinely a significant loss, and simply learning about new tools does not have the same value as they do not yet have a network to share this information with.

From this simple comparison, we can already identify a few key dimensions on which players and their goals may vary. For instance, the two individuals vary in what resources they have at their disposal, both in terms of material and social resources. They also vary in what constitutes a victory or loss, or more simply, what they are trying to achieve. However, both seem to take an approach that prioritizes researching existing tools, rather than, for instance, trying out tools and subsequently adapting them. By articulating even three dimensions, we can already begin to map out a range of possible "metagames" (i.e., individual approaches to AT adoption), with different combinations of values on these dimensions suggesting further potential approaches that are valuable to consider when designing new AT.

To a certain degree, this premise boils down to the rather ordinary statement that "different people want different things", and that disabled people are not a monolith. However, by leveraging the framework of metagaming, we can better characterize some of the specific dimensions in which AT user goals vary, further supporting us in employing practices like developing community metas and strategy guides for AT adoption.

Chapter 6

Discussion

Having completed these three projects, I now return to the higher-level discussion of my thesis:

> **Analyzing disabled technology adoption with a lens of game design can reveal new opportunities for both designing and leveraging access technologies.**

In order to finally demonstrate this statement, I explore three key facets of this statement, each encompassed in one of the following sections in this chapter:

- First, in Section 6.1, I revisit insights related to disabled technology adoption raised across the three preceding chapters, setting up context for **"analyzing disabled technology adoption"**.
- Next, in Section 6.2, I continue this analysis in the context of the "Game of Accessibility" framework (introduced in Chapter 1). This enables applying **"a lens of game design"**, to begin to **"reveal new opportunities for both designing and leveraging access technologies."**
- Finally, in Section 6.3, I introduce a "Decision Tree Model of Accessibility", which shows a larger-scale potential application of the game of accessibility framework. This model

similarly leverages insights from game studies to present a new formalization of how people navigate *decision-making* related to accessibility challenges. I then explore the implications of this model, and specifically discuss the potential for games to be leveraged as an exploratory domain for developing further insight about accessibility and the **"new opportunities for both designing and leveraging access technologies"** that this model produces.

For convenience, in the coming sections I occasionally refer to each of the three projects using shortened versions of their chapter names: *"Hard Mode"* refers to Chapter 3's study of accessibility in game adoption; *"Modeling"* refers to Chapter 4's study of how PWD provision access and our articulation of the calculative model of accessibility; and *"Hard AT Work"* refers to Chapter 5's exploration of AT Adoption.

6.1 Disabled Technology Adoption

Across the three projects presented in the previous chapters, we have explored the topic of disabled technology adoption from three distinct directions:

- In *Hard Mode*, we first explored the more narrow context of disabled *game* adoption, particularly centering the perspectives of disabled *gamers* and how adoption directly factors into their gameplay.
- In *Modeling*, we then broadened the scope to include non-gaming perspectives and technologies, and specifically explored the demands in applying technology for accessibility.
- Finally, in *Hard AT Work* we returned to disabled technology adoption, this time focusing on *AT* adoption.

Though each project has its own individual takeaways, there are several key themes we can identify spanning the works.

Firstly, across all three projects, we can note the important role time plays in disabled technology adoption. In *Hard Mode* and *Hard AT Work*, this noticeably manifests in our three-stage model of Discovery, Evaluation, and Adaptation for game and AT adoption. Rather than regarding disabled technology adoption as a singular, instantaneous event, this model emphasizes the important steps of a sequential process, much of which might occur before ever directly interacting with the technology.

In addition to being temporal, disabled technology adoption is also heavily affected by an individual's environment and context. This appears very saliently in *Modeling*, where we present contextual factors as a key variable in our model of accessibility. *Modeling* also introduces the concept of an AT repertoire, where we can observe that an AT's usage is heavily influenced by what other AT a person already has available to them, thus making it near-impossible to consider the design of one tool in isolation. The examples presented in *Hard Mode* and *Hard AT Work* also show the contextual nature of disabled technology adoption, in part as we consider what resources participants leveraged throughout the process. In both studies, we noted a combination of social resources, "expert" and "official" resources, and community-built collaborative resources that influenced how a person could approach the process of technology adoption. With such a range of resources, it becomes even harder to imagine a realistic model of disabled technology adoption that does not account for the variation brought on by contextual factors.

Finally, we can also consider the interplay between individual and community action throughout disabled technology adoption. As previously discussed, community-built collaborative resources were central to the adoption process in both *Hard Mode* and *Hard AT Work*. This also relates to our consideration of individual values as contextual factors in *Modeling*. Many of the values discussed were socially-informed, with factors like social acceptability or family values heavily influencing how a disabled person might want to approach an accessibility problem. Because of this, even an individual acting fully independently is still affected by community. This, in turn, changes how

we ought to scope design for disabled technology adoption: rather than viewing adoption as a fully individual process, we need to consider it as a multi-stakeholder process that also has an individual component.

6.2 The Game of Accessibility

To reintroduce the concept of the Game of Accessibility, the central conceit is that much of how people navigate access challenges maps quite well onto how people play games: navigating a challenge, constrained by certain rules and [physical] mechanics, with an ultimate goal of surpassing the challenge while optimizing for certain objectives.

As we consider the takeaways of the projects presented in the preceding chapters, we can further characterize the game, its rules, and how "players" (i.e., people with disabilities) might strategically navigate it. In doing this, we can begin to consider how existing theories of games and play might apply in this space, potentially surfacing new insights about how AT designers and technologists might better support PWD in navigating accessibility challenges.

6.2.1 Characterizing the Game

The traditional definition of a game (i.e., Salen & Zimmerman's definition [139]) features three central components: a challenge (or "conflict"), constraints (or "rules"), and an outcome.

Challenge and Conflict

We can first consider how to define the challenge: in a simple sense, the 'challenge' of inaccessibility is a task a person aims to complete that does not necessarily align with their abilities. This loose definition is, of course, fairly reminiscent of the social model definition of disability [113], which centers mismatch between expectations and ability as the source of inaccessibility.

However, we can contribute additional detail to this challenge definition using some of the insights developed so far. In *Modeling*, we defined four distinct types of access barriers: Failure Point, Usability, Bodymind, and Future Impact– we can employ each of these to more clearly define the specific challenge. In the case of a Failure Point barrier, the challenge is to make an impossible task possible, or to find a workaround. For Usability barriers, we have a particular quality of experience completing a task that we want to improve or modify. For Bodymind barriers, the objective is to find a way to alter the current state of one's bodymind to reach a more tolerable state. And for Future Impact barriers, the goal is to estimate and calculate what consequences are acceptable as trade-off for a particular task.

We can also identify "meta" challenges that are byproducts of the larger process of trying to navigate inaccessibility. For instance, in order to navigate some access barriers, a person may need to have a certain type of AT in their repertoire; but as we know from *Hard AT Work*, the stakes of adopting AT are high, and finding the right AT to add to a repertoire is a challenge in and of itself.

Rules and Constraints

The rules of a game can be understood as the constraints that define what is actually possible when navigating the game's challenge– in this case, trying to navigate an access barrier. Returning to our concepts in gaming (discussed in Section 2.4), this is understood as the "space of possibility", or the set of possible states that can be reached in a game; and in the context of the Game of Accessibility, this is the set of possible outcomes of attempting to navigate an access barrier.

A key factor in defining what's possible is the repertoire a person has: depending on their AT, they might choose to approach certain barriers in a particular way. We can also connect this to the concept of difficulty: depending how a person's AT (or rather, ability + AT) is (mis)matched to a certain challenge, they might have a range of options in how they can approach the challenge, or they might be constrained to a single (potentially difficult) approach. For instance, consider a

blind person navigating an inaccessibly built webpage: if they only have a screen reader in their repertoire, they are forced to navigate a more difficult challenge than if they also had access to a visual support tool like BeMyAI. It's possible they might still opt to navigate with the screen reader– for instance, maybe they're hoping to save their BeMyAI credits, which have a monetary cost; but their overall space of play is less constrained, as they have options to decide between.

Adaptation also plays an important role in defining the constraints of the game: if the player can modify their tools or how they use them, new options are opened up in our space of possibility. Returning to the four approaches to Adaptation we saw in *Hard Mode*, we can extrapolate what those approaches could look like in the Game of Accessibility:

- *Adapting the game* was understood as changing the central systems of a game– this most naturally maps onto the idea of modifying AT, which is the central system of this Game.

- *Adapting the system* centered around finding ways to modify what challenges were presented, which can be understood as changing the environment or set of access barriers a person encounters.

- *Adapting play* involves changing the rules of the game or how one attempts to play it. This seems to align with the premise of changing the approach (i.e., AT or how it is used) or potentially goal when navigating an access barrier.

- *Adapting expectations* involves changing a person's sense of what their experience with a game will be like. In the Game of Accessibility, this most neatly maps onto the idea of setting one's expectations of what they can or cannot do– effectively, accepting that some access barriers may be insurmountable. Or, this could be understood as changing one's standards and evaluation metrics: maybe I can't navigate the supermarket in a "normal" way (by society's standards) but I can still make it through my own way.

Outcome and Objectives

Finally, we can consider what specific outcomes are desired when navigating an access barrier in the Game of Accessibility. Returning to the calculative model from *Modeling*, we can consider how contextual factors play into determining what the actual goal is: rather than "accessibility" having a single universal definition, we understand that each individual's values and background affect what is considered a 'good' outcome (or, perhaps, a "win condition"). This brings into question what metrics are used for evaluating the success of a strategy in this game: if there is a way to complete an otherwise uncompletable task, but it goes against all of a person's values or bears too high a cost, do we still expect that to be considered a viable way to 'win' here?

6.2.2 Analyzing Strategy and the "Meta"

In the simplest mathematical sense of a game, strategy and the ability to optimize one's gameplay is a fundamental attribute that defines a game.

As we consider the Game of Accessibility, we can easily see how strategy manifests: in *Modeling*, we saw individuals developing complex strategic models to account for various contextual factors when performing 'consequence calculus'. However, not all players take the same approach to strategizing in a game; and, by extension, we can understand that not all PWD take the same approach to strategizing in the Game of Accessibility. And further, it is widely understood that a person's strategy, and even their ability to strategize, can evolve and grow over time as they gain more experience with a game– if we continue this parallel, we can suppose that this may be the case in the Game of Accessibility as well.

Consider, for instance, the difference in how a person who has been blind their whole life might approach a particular accessibility barrier compared to someone who recently became blind after an accident. If the barrier is something a person regularly encounters, the person with more

experience navigating it will likely have less of an issue. However, even if the barrier is something both are encountering for the first time, the person with more experience *figuring out how to navigate access barriers* will still likely overcome the barrier more easily.

This is not a groundbreaking concept: disabled folks have long turned to their broader communities to support each other in navigating certain challenges, with some even taking on the role of a "disability doula" to teach some of this strategy to newly disabled individuals. However, there are limitations to this system. Even finding a disabled community may be a challenge for some (not to mention the difficulty of learning to ask others for help), and with new challenges and tools regularly emerging, knowing the current best strategy can be a complex task.

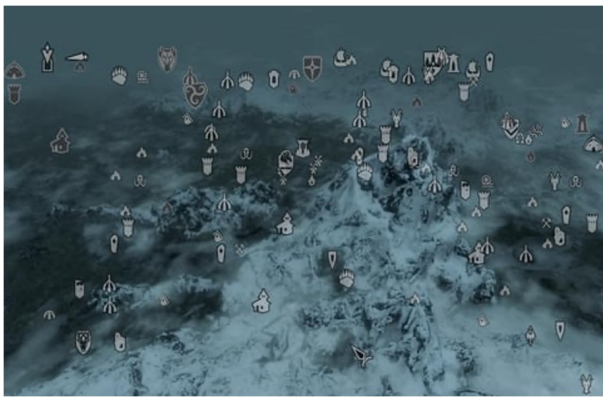
In gaming, a "meta" is an articulation and categorization of the current best strategies for playing a particular game. This concept is particularly common in competitive multiplayer games, where periodic updates to the game and changes in the community will regularly change what the most effective strategies are. [156, 120, 119]

Prior work has explored many facets of metas in games, including establishing clear models of how they can be structured and analyzing how player communities develop, evolve, and interact with them [156, 119]. Considering how prominent metas have been in gaming communities for the last two decades, this framework could serve as an effective means of understanding strategy and its underpinnings in the context of the Game of Accessibility.

Using this approach to analyze accessibility challenges, we can begin to see new ways for "players" (i.e., PWD) to communicate opportunities, strategies, challenges, and unsolved problems in more varied contexts and across a broader community.

As we consider new ways to communicate about strategy of navigating accessibility challenges, we can also consider how we could use analytical models in this space– a concept I explore further in Section 6.3.

(a) *Sid Meier's Civilization VI* map interface, combining "active" areas (colored terrain), "inactive discovered" areas (faded terrain), and "undiscovered" areas (featureless tan regions)



(b) *The Elder Scrolls V: Skyrim* map interface, combining overall landscape and encoded symbols for landmarks, using light/dark inversions to indicate whether a point has been "discovered"

(c) *The Elder Scrolls V: Skyrim* compass, providing local guidance by encoding distance via symbol size and opacity, high-level category via shape, and other attributes via color (e.g., red enemy, black symbol to indicate "undiscovered")

Figure 6.1: Sample of navigation interfaces from popular video games

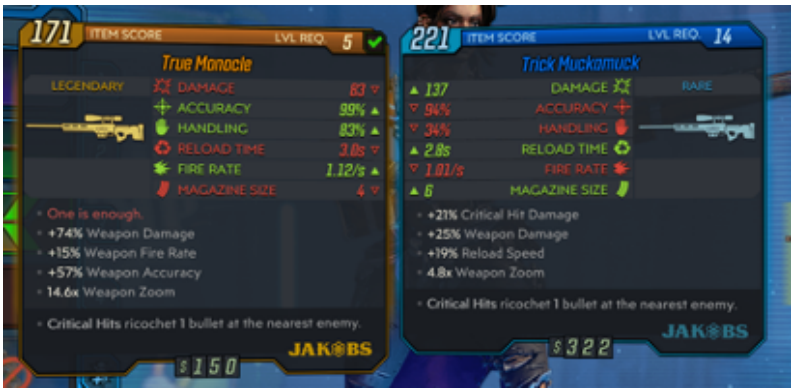
6.2.3 Communicating About Access

Another affordance of a game framing of accessibility is the potential to leverage existing well-established metaphors and communication modes to articulate nuances of accessibility in familiar ways.

For instance, consider the well-established design pattern of maps in video games. Some prior work has already explored the variety of designs employed across a wide range of games (e.g., [30, 42]), and many gamers have learned how to use these many different interfaces to extract relevant information for their gameplay. Figure 6.1 shows a few examples of these maps,

(a) *Pokémon: Brilliant Diamond* stat screen, showing absolute performance in six dimensions

(b) *Mario Kart 8* stat screen, showing absolute performance (individual bars) and relative performance (side-by-side comparison)



(c) *Borderlands 3* stat screen, centering direct comparison (arrows/colors per stat), *some* absolute scores (e.g., accuracy percentage), and synthetic "ratings" to aid overall decision-making (the "item scores" in the top corner)

Figure 6.2: Sample of stat screens from popular video games

emphasizing how they can vary in level of detail, sense of scope/context, and information provided about journeys between points. If we purposefully frame the process of AT Adoption as a 'journey', we can make effective use of this map metaphor. At any given point, there are various diverging 'paths' a person might be able to go down, and a range of 'destinations' where they might end up, each with their own set of outcomes (e.g., combinations of AT, modifications, experience trying certain tools). By centering discussion of accessibility in the context of a game, we can more effectively leverage the design metaphor of a map as a means of communicating information about where a person is on this journey, where they might be able to go, and so on.

Gaming design patterns also include more traditional forms of data visualization (sampled in Figure 6.2), which have also received their fair share of discussion in the HCI and Data Visualization community (e.g., [17, 121, 165, 24]) for how they support frequent, context-specific analysis of in-game data while still ensuring the interaction is relatively lightweight. The 'stat screen' (Figure 6.2(b) and (c)) is one common pattern across games that enables various forms of evaluation of a particular tool, character, or other game element, often with a goal of knowing how that element compares directly to other options or how it ranks in an absolute sense. This pattern could be easily be extended into the space of AT Adoption: for instance, imagine being able to compare two similar ATs side-by-side and see which dimensions they vary on, and to what degree. Or, consider someone whose AT options are constrained by price: being able to understand how well an affordable AT option fares on an absolute scale of AT performance fundamentally changes a person's ability to evaluate their options.

6.3 The Decision Tree Model of Accessibility

Another opportunity of viewing accessibility through a games-based lens is the opportunity to model complex accessibility interactions as a series of discrete decisions, similar to abstract representations of (video) games as decision trees [106, 64, 123]. By modeling accessibility interactions this way, we can model the specific trade-offs and bits of consequence calculus being performed, which we have developed into a **Decision Tree Model of Accessibility.**

The **Decision Tree Model** is, in short, an accessibility framework that considers how various decisions, whether explicitly accessibility-related or not, influence what challenges, opportunities, and other situations arise later on.

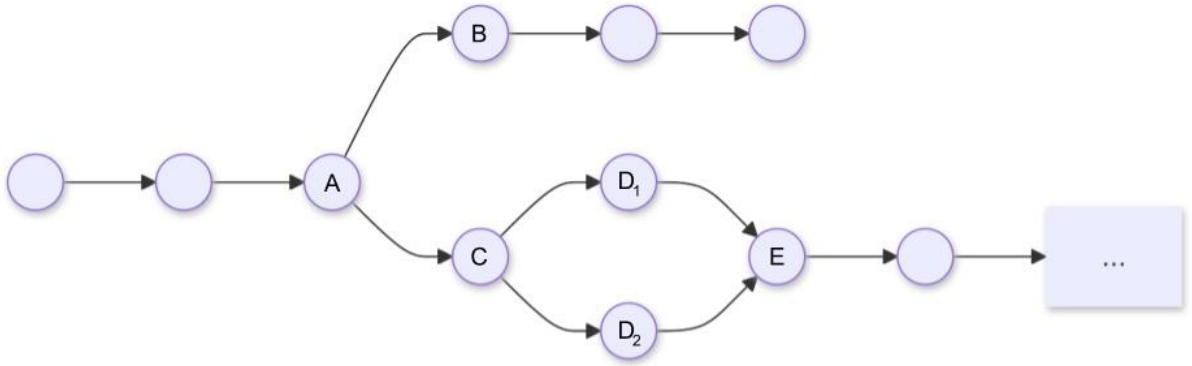
This framework draws significant inspiration from Mack & McDonnell et al.'s *Consequence-Based Accessibility* framework [100], which in turn laid the groundwork for our calculative model

of accessibility in *Modeling* (Chapter 4 and [101]). Notably, all three framings center a causal relationship between accessibility-related scenarios: Consequence-Based Accessibility factors in how chronically ill individuals account for anticipated consequences, and our calculative model emphasizes how personal identity and values influence the access decisions people make.

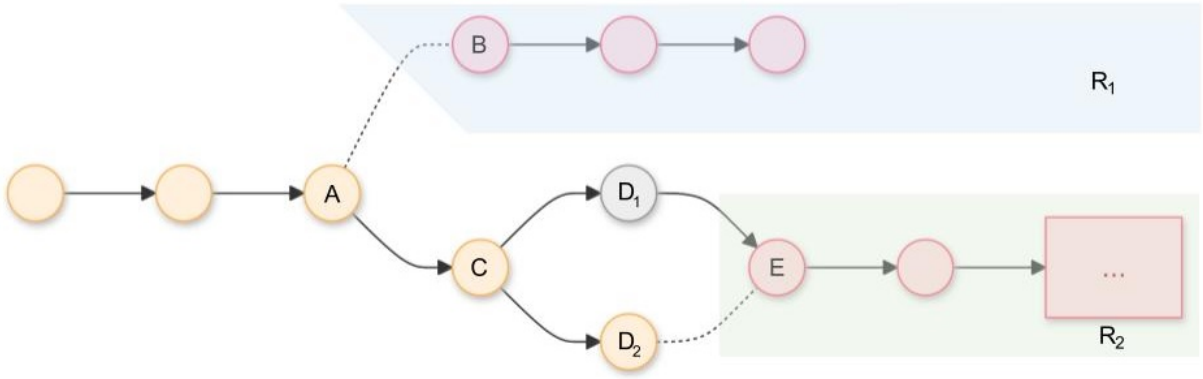
In contrast, the decision tree model centers how specific decisions affect **what specific accessibility scenarios subsequently arise**. For instance, consider the following scenario: suppose a person with chronic fatigue needs to travel two miles for an important business meeting. His repertoire (as defined by the calculative model) consists of a bike and a rideshare app. Per a consequence-based accessibility framing, he recognizes that if he takes his bike, he will likely tire shortly after the meeting; however, per his consequence calculus, he decides this is preferable to paying for a rideshare.

After the meeting ends, the clients unexpectedly propose going to happy hour, and he is faced with another decision: power through his oncoming fatigue and accept the consequence (major brain fog the following day) to satisfy the client; or decline the invitation to manage his fatigue but risk damaging his professional relationship. Neither is a "good" outcome, but he is forced to choose between the two.

Now consider what would have happened if he used the rideshare app, rather than the bike: although he would have taken on the financial cost in the first scenario, there would not be a risk of incurring brain fog by going out to happy hour in the second scenario, and thus an easy choice to avoid damaging his professional relationships. Ultimately, after *both* scenarios, deciding to go with the rideshare in the first scenario produces the best possible outcomes. However, this decision is only clear **if the full sequence of scenarios is known in advance.**



(a) A Decision Tree Model representation of a Space of Possibility.



(b) One potential **Accessible** Space of Possibility. *(Dashed lines represent inaccessible paths.)*

Figure 6.3: Example decision trees representing (a) the Space of Possibility and (b) the Accessible Space of Possibility. In (b), the path from A to B is inaccessible, removing region R_1 from the Accessible Space of Possibility. The path from D_2 to E is also inaccessible, meaning that region R_2 is in the Accessible Space of Possibility only if the player chooses option D_1; selecting option D_2 effectively reduces the reachable region of the game.

Model Applications: Path-Finding and the "Wall Effect"

Mathematically, there is additional analytic potential in representing accessibility challenges as a decision tree. Given that decision trees are a kind of directed acyclic graph (DAG), there are many existing graphical analysis algorithms that could be leveraged, such as Dijkstra's Algorithm and the Floyd-Warshall Algorithm.

Dijkstra's Algorithm is used to find the shortest path between two nodes in a DAG. Supposing we can interpret a series of accessibility choices as a DAG with each edge weighted according to the consequence-based "cost" of that choice, we could employ Dijkstra's to find the lowest cost (i.e., "most accessible", by some metric) path from the first decision point to the final outcome.

The Floyd-Warshall Algorithm is another graph algorithm with potential applications when representing accessibility choices as a DAG. Floyd-Warshall calculates the all-pairs minimum distance between nodes in a DAG (in some senses, scaling up Dijsktra to a full graph). A particular benefit of Floyd-Warshall in this context is its application in finding "unreachable" nodes in a graph, particularly which nodes do not have a path that connects to the ending node. Using a binary calculation of "is accessible" vs. "is inaccessible" for edge weights between connected nodes (i.e., a weight of K or higher is considered "is inaccessible"), a pruned version of the original network can be calculated that then exposes impossible paths (i.e., disconnected nodes).

Identifying disconnected nodes can then be used to identify instances of a phenomenon I have come to call the "Wall Effect": situations where an experience is accessible up until a certain point, but ultimately there is no accessible path that fully goes from the start to the finish. We developed this concept of the Wall Effect in the context of gaming, informed by experiences participants shared in interviews in the study for *"Hard Mode"*.

Prior work in game accessibility had identified certain instances of this phenomenon (e.g., [125, 53]). However, prior work had not articulated an abstracted form of this phenomenon; but

using the decision-tree framing, we can clearly specify this scenario as an instance where there are two or more disconnected portions of the game's decision tree.

Extending this into real-world scenarios (e.g., the one described in Figure 6.3), we can more clearly see the potential of identifying instances of the Wall Effect in accessibility contexts. Using the decision tree model, we can find pairs of nodes that have no path between them. For instance, perhaps a certain response to a future-impacts barrier early in a timeline prevents someone from being able to access later desired outcomes due to accumulated fatigue. We can understand the branch of the decision tree with this response to the future-impacts barrier an instance of a wall: perhaps there are additional nodes in the tree that can still be reached, but ultimately that portion of the tree is cut off from the desired later destination, no matter what combination of decisions is subsequently made.

Games as an Exploratory Domain for the Decision Tree Model: *The Accessible Space of Possibility*

We can use the Wall Effect as somewhat of a case study: part of what enabled us to identify the Wall Effect was a shared understanding of the full scope of what could be possible in a game (i.e., the Space of Possibility [139]), juxtaposed with what portion of the Space a particular disabled player was actually able to reach. In the context of games, we can begin to understand this as an articulation of the "*Accessible* Space of Possibility", i.e., the full scope of experiences a disabled person can have in a game when the Space of Possibility is constrained based on accessibility thresholds.

Returning to the Game of Accessibility, there are clear benefits to being able to map out a person's Accessible Space of Possibility, but also some key limitations. The most evident limitation is that the scale of the Game of Accessibility is magnitudes larger than a video game– it is simply intractable to meaningfully estimate the Accessible Space for a person within the full Space of "the

entire world". However, in smaller, contained systems, such as a specific building or a multi-stage activity, mapping out the Accessible Space can be more plausible. Once an Accessible Space is mapped out (or perhaps several, for a variety of people), this can act as a data-driven tool for identifying meaningful locations for targeted accessibility improvement.

Consider, for instance, a gym with a range of exercise machines and various free weights, and suppose we map out the Accessible Space of Possibility for a particular blind adult. A simple accessibility assessment might surface a handful of barriers: say, the treadmills have features on an inaccessible touchscreen, and the free weights don't have tactile indications of how much each one weighs. However, if we map out the Accessible Space, we can see that the inaccessible touchscreen does not cut off additional parts of the Space; but the lack of tactile marking on weights cuts off the individual from being able to use any of the equipment that require free weights (such as various benches) or participate in the gym's exercise classes that regularly use free weights. Therefore, all else considered equal, there is a clearly articulable reason to address the issue with the free weights first, as its inaccessibility has more wide-ranging ramifications.

It is important to note that this insight could, of course, be reached in other ways. However, the process of mapping out the overall Space of Possibility and identifying the Accessible Space within it could potentially enable non-experts to more easily reach this conclusion and aid further communication and rationale about what barriers are more pressing to address.

6.4 Conclusion

Throughout this dissertation, we have explored this concept of the "Game of Accessibility": a game that disabled individuals are forced to play, whether they want to or not. Through exploring disabled insights from game adoption, accessibility modeling, and AT adoption, we have begun to understand just how the game works and, more importantly, how disabled individuals can

strategize around the game to make the game more enjoyable (or at least less painful) for themselves and others. Accessibility is not a zero-sum game: by contributing to communal understanding of how to play the game, the game's "players" can find new ways for their whole community to succeed, rather than having to fight every battle on their own.

Not all games are fun, and not all games are clearly winnable. However, community collaboration can at least help turn the Game of Accessibility into something that brings people together and drives progress. Even if the challenges of the game never end, it remains important to understand and support individuals and communities as they play.

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