Exploring the Accessibility of Crypto Technologies

Nash Lyke
nkl8137@rit.edu
School of Information
Rochester Institute of Technology
Rochester, NY, USA

Benjamin M. Gorman
bgorman@bournemouth.ac.uk
Bournemouth University
Bournemouth, UK

Garreth W. Tigwell
garreth.w.tigwell@rit.edu
School of Information
Rochester Institute of Technology
Rochester, NY, USA

ABSTRACT

Blockchain and crypto-based technologies are a rapidly-growing domain on the cutting edge of web technologies; however, little research has examined their accessibility for users with disabilities. We focused on a specific area of this domain by completing accessibility audits of four major cryptocurrency exchanges and administered a questionnaire to disabled people to understand potential accessibility challenges. Our accessibility audit revealed many severe accessibility violations among each of the major exchange sites. Participants (n = 72, 23 crypto adopters) reported a wide variety of accessibility concerns with cryptocurrency exchanges and using cryptocurrency itself, which presented barriers to access and adoption of these technologies. We discuss the implications for our findings and propose future areas of work in this domain.

CCS CONCEPTS

• **Human-centered computing** → **Accessibility**.

KEYWORDS

Accessibility, Cryptocurrency, Blockchain

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1 INTRODUCTION

We are moving toward a more decentralized iteration of the World Wide Web, often called the emergence of Web3 [10, 16, 47]. This is characterized by the growth of *crypto*: applied blockchain technologies such as cryptocurrencies or Non-Fungible Tokens (NFTs) [16, 31, 42]. Crypto empowers users by decentralizing record-keeping, making peer-to-peer transactions anonymous, transparent, and secure. By spreading the responsibility of verifying blockchain integrity across its users, it aims to make web technologies more inclusive and fair. Web technologies are salient for their universality, empowering all users with equal access to their many functions [12]. For crypto to truly promote equity and fairness, it must be accessible for all users, regardless of their abilities. However, it is not clear how accessible crypto is for disabled people.

Cryptocurrency is often the first entry point for new blockchain users, since the mechanics of decentralized technologies are not well-understood by the general public [21, 28, 45]. As cryptocurrency exchanges are the primary method of buying and selling most cryptocurrencies and NFTs, we determined that assessing accessibility among the largest exchanges was critical for exploring what challenges disabled people may face when utilizing crypto technologies. We conducted accessibility audits of four cryptocurrency exchanges, Binance.us, Coinbase.com, Crypto.com, and Kraken.com, to determine their adherence to WCAG 2.1 and IBM web content accessibility guidelines. We then conducted a qualitative questionnaire with disabled people to explore their experiences with crypto. Our audits revealed severe accessibility violations among all crypto exchanges. Our participants highlighted accessibility barriers throughout all facets of cryptocurrency technology use, particularly for assistive technology use. We contribute a novel analysis of accessibility in crypto, providing first-hand inspection and user accounts of accessibility challenges in its technologies. We make recommendations for improving the accessibility of crypto.

2 BACKGROUND & RELATED WORK

2.1 Boons and Barriers to Crypto Adoption

Interest and adoption of crypto have grown rapidly in recent years, predominantly through cryptocurrency [17, 18, 21–23, 38, 40, 41]. Adopters are often wealthy and highly educated young men, and unsurprisingly endorse a far greater understanding of blockchain than non-adopters [17, 21, 45]. Most choose to adopt cryptocurrency as a speculative asset, though some use it for cashless payment. Some adopters cite ideological interest as a driving force, highlighting its decentralized, largely unregulated form of digital currency as a "monetary revolution" [27, 37].

Previous work highlighted several barriers to crypto adoptions: poor understanding and distrust of crypto [6, 7, 35, 45], as well as poor usability in crypto technologies [6, 15, 24, 46]. The underlying mechanics of blockchain technologies are complex and often obscure to the general public, creating a great deal of misunderstanding and distrust in crypto, and discouraging adoption [6, 31, 45]. There is also ideological distrust of crypto's decentralized, deregulated nature, which may be perceived as risky and more prone to fraudulent activity in financial contexts [35, 45]. Cryptocurrency exchanges and sites, the most common method of utilizing crypto, suffer from a host of usability issues which also discourage adoption [6, 15, 24, 46]. New adopters must acquire an understanding of trading, as well as site- and application-specific knowledge for

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completing transactions in their respective exchanges that is simply not necessary for credit/debit payments [6, 15]. Cryptocurrency exchanges offer rich data and functionality for expert users via price monitoring and other tools, but severely overload novices [15]. This overload is exacerbated by poor onboarding and error recovery across wallets and applications, leaving novice users frustrated when faced with long, irreversible, pending transactions, or surprising hidden fees [6, 11, 15, 46]. New users may be bewildered by crypto wallets, as they function more similarly to bank accounts than actual wallets [24]. Furthermore, some crypto wallet applications are prone to crashes or other interface bugs leading to lost wallet access, lost transactions, and lost currency [46].

2.2 Accessibility in the Financial Sphere

Though no work has examined the accessibility of crypto or particular cryptocurrency services, some previous studies have examined accessibility in adjacent financial services, e.g., online banking [25, 49] or e-commerce [39, 43]. Common accessibility problems found throughout many websites and applications are also found within banking and e-commerce sites [39, 43, 49], such as poor element labeling, color contrast, and error recovery. These issues exacerbate intimidation surrounding digital financial services for disabled users, as mistaken inputs can lead to accidental transactions and catastrophic financial outcomes [25]. This is especially concerning in crypto because blockchain transactions are irreversible by their nature [46].

3 RESEARCH QUESTIONS

Since prior work focused on poor accessibility in more traditional financial services and only usability in crypto, we were specifically concerned about the accessibility of crypto technologies and services. To establish an understanding of accessibility in crypto, we sought to determine: 1) *Are common crypto technologies accessible*? and 2) *What accessibility challenges do disabled users face while accessing crypto technologies*? To answer these questions, we first conducted accessibility audits of major cryptocurrency exchanges to determine if they have prevalent accessibility violations. Then, we distributed a questionnaire to understand ownership patterns and accessibility concerns from the perspective of disabled crypto adopters and non-adopters.

4 STUDY 1: ACCESSIBILITY AUDITS

4.1 Cryptocurrency Exchanges

We audited four cryptocurrency exchange websites: Binance.us, Coinbase.com, Crypto.com, and Kraken.com, for their compliance with WCAG 2.1 and IBM Accessibility Requirements. These exchanges were chosen as they were the highest rated at the time of auditing in early 2022 by CoinMarketCap [3] and CoinGecko [1], two prominent cryptocurrency market trackers. Their exchange ratings were based on their high overall volume of currency, high weekly visits, high liquidity, and high ratings as reputable markets. We also limited ourselves to exchanges available in the US because the primary auditor (first author) was located in the United States. Some features were disallowed among the exchanges we selected due to federal and state government regulations.

4.2 Procedure

4.2.1 Accessibility Guidelines. We adapted a previously-established, comprehensive checklist of potential accessibility violations [30], based on a combination of the WCAG 2.1 [4] and IBM's web content and application accessibility guidelines [2]. This checklist was organized by WCAG 2.1's four principles of Web accessibility and was used as a guide for auditing. Each section of checklist items are listed in Tables 1, 2, 3, and 4 (see Appendix A). We paid particular attention to common accessibility violations found in other literature on web and mobile application accessibility, such as low-contrast text and missing alt-text (e.g., [5, 26, 34]). The goal of audits was not to generate a comprehensive list of all potential accessibility concerns; rather, we sought to evaluate the experience of using crypto exchanges for users with an array of access needs, highlighting where accessibility issues may create critical barriers for individuals with impairments.

4.2.2 Assessment Approach. A sighted auditor manually audited exchange sites to gain a qualitative understanding of accessibility barriers. The researcher began the audits on a Windows computer using Firefox, Chrome, and Microsoft Edge's built-in accessibility checkers, as well as WebAIM's WAVE Web Accessibility Evaluation Tool [48], to get a broad sense of accessibility and note major violations, such as missing alt-text and poor color contrast. We were careful not to rely solely on automated checkers, as previous literature has established their inadequacy for catching nuanced accessibility violations [34, 44]. Then, we would inspect each element on the page. We recorded compliance and guideline violations and provided notes on the nature of violations. We checked whether image alt-text was necessary for context or if the image was decorative and did not require alt-text. We would first traverse the page with a mouse and keyboard, then with only a keyboard. Lastly, we traversed pages via screen reader, initially on browser versions of each site using Windows Narrator and then subsequently on mobile versions of each site using Android TalkBack. This was to ensure consistency and robustness across separate testing platforms.

4.2.3 Critical Pathway for Task Assessment. The auditor would get familiar with the layout of the computer website, making a note of the landing page, sign-up/login screen, and trading page. We determined these pages were most important for auditing as they represent the critical pathway to be able to buy and sell cryptocurrencies on these exchanges. Then, starting with the landing page and working as far as possible on the US site to trading, the auditor would check each page for all accessibility guidelines.

4.3 Data Analysis

We determined a guideline failure rate as a percentage of violated guidelines from the total number of guidelines at each severity rating (A, AA, AAA, IBM). For guidelines with a high volume of simple pass/fail ratings, such as in alt-text or inaccessible UI components, we calculated a percentage of inaccessible elements (inaccessible element rate, IER) calculated from the total elements in the category. We considered any alt-text violations as a single WCAG A-severity Perceivability violation for analysis. Finally, we present examples of accessibility challenges to highlight how users with disabilities may be discouraged or barred entirely from utilizing crypto exchanges.

5 ACCESSIBILITY AUDIT FINDINGS

Our audits revealed many accessibility violations that affected user experience and access. All sites had critical issues which limited keyboard-only or screen reader use. These were prominent from the beginning of site navigation and throughout the sign-up and trading pathways. They featured common web accessibility issues, e.g., poor element labeling, poor color contrast, etc., but were uniquely concerning given the financial stakes of cryptocurrencies. Crypto.com had the most WCAG 2.1 accessibility violations, but Binance.us had the highest IER. Alternative presentations of our task assessment findings can be found in Appendix A in Tables 5, 6, and 7.

Perceptibility Violations: All sites either failed (Binance; Kraken) or had only AA-rated color contrast. Binance had the greatest number of alt-text violations (*IER* = 39.3%), followed by Crypto.com (*IER* = 20.0%). We found no alt-text violations on Coinbase or Kraken; all images were either properly named or purely decorative.

Operability Violations: We found keyboard traps on Binance and Crypto.com in their navigation headers. Each site featured at least one page that failed to utilize heading HTML elements, thus making the site layout difficult to understand with a screen reader. We found unreachable elements on Binance and Crypto.com; they were especially disruptive to keyboard-only and screen reader use. For instance, keyboard-only users on Binance would not be able to access the login link or certify their age when creating an account.

Understandability Violations: We found poor element labeling on links, buttons, and dropdown menus on all sites, which made screen reader use unpredictable. These were especially problematic in sign-up forms, making account creation vague and difficult.

Robustness Violations: Sites functioned similarly across browsers and screen readers. We found Binance to be the least robust site as it featured the most inaccessible elements by percentage (93 elements, *IER* = 71.0%) and was least accessible with keyboard-only or screen reader use. It was followed by Crypto (14, *IER* = 14.0%), Kraken (11, *IER* = 5.7%), and Coinbase (2, *IER* = 2.8%).

5.1 Task Assessment Findings

5.1.1 Navigating Landing Pages. Landing pages for crypto exchanges were prone to perceivability violations which made the sites more difficult to understand, often due to poor use of alt-text on marketing materials. For instance, Crypto.com and Kraken presented users with videos which auto-play on its landing pages; however, the videos have no text-alternative presentation for screen reader users. Neither were captioned for deaf or hard-of-hearing (DHH) users, but also did not feature sound—it would be helpful if a caption at least confirmed there was no sound to remove ambiguity a DHH user might experience. We found unreachable elements in the headers of Binance and Crypto.com's landing pages, making whole areas of the sites inaccessible without a mouse. TalkBack could not access links in Crypto.com's mobile hamburger menu, again limiting site access. Coinbase's header sign-up and sign-in buttons lacked a keyboard indicator. Binance utilized a table to present prices of highly-traded cryptocurrencies, but could not be understood with a screen reader as it did not provide column and row information. It also had poor link labeling, making site interactions unpredictable for screen reader users. Beginning to use crypto exchanges was difficult with keyboard-only or screen reader use.

5.1.2 Signing Up. Binance, Coinbase, and Kraken allowed users in the auditor's geographic area to create accounts, but barred the auditor from completing transactions or completing account verification. Crypto.com disallowed users from the primary auditor's geographic area access to the rest of its site, stopping its audit at the landing page. Every element on Binance's sign-up form lacked appropriate labeling for screen readers, making it impossible to know what information was needed to create an account. Kraken had fewer disruptive errors but still lacked meaningful labeling on some elements, such as its location dropdown menus. Coinbase again lacked a focus indicator for its sign-in and sign-up buttons in its header, and it neither maintained user information for inputs, nor provided error recovery information in a way that could be perceived with a screen reader.

5.1.3 Trading. Only Binance and Kraken allowed the auditor access to its trading pages, though the auditor could not complete a transaction. Kraken had some unnamed links, but none were essential to the trading process. Trading on Binance was very difficult to simulate with a screen reader or keyboard. Areas of the header, such as "Trade", "Resources", "Notifications", and "Profile" were all unreachable with a keyboard. The cryptocurrency price trend graph was not focusable with a keyboard and could not be presented to a screen reader user. Links throughout the page were not labeled, which was especially concerning given that users would be making financial transactions on the page. Most concerning, however, was the lack of labeling or instructions in the form where users purchase or sell their cryptocurrencies, making trading effectively inaccessible. The selector for switching between buying and selling was also not focusable with a keyboard, leaving screen reader and keyboard-only users stuck only being able to purchase crypto.

6 STUDY 2: QUESTIONNAIRE

6.1 Participants

Participants (n = 72; 39 women, 1 non-binary) were disabled individuals. Less than a third of participants reported having owned or or ever utilized crypto technologies (n = 23; 32.4%). Most participants (90.3%) were blind/low-vision, with 20.8% having a hearing, motor, or cognitive impairment as well. Our participants were between the ages of 19 and 75 years old (*mean* = 42.4, *SD* = 13.9) and highly educated, with 69.5% having achieved at least an undergraduate degree. Sixty-five utilized assistive technologies (AT) in their day-to-day lives, with 62 participants being screen reader users.

6.2 Procedure

Our questionnaire first asked for demographics such as age, gender, and educational background. We asked participants to share their disability history and any assistive technologies they used. We then asked about their experiences with crypto, such as if they owned cryptocurrencies, how they bought, sold, mined, or staked cryptocurrencies, how they tracked cryptocurrency prices, and challenges they faced in doing so, due to accessibility or otherwise. We asked both participants who did and did not endorse experience with crypto to share their habits with personal finances. This was to determine if accessibility challenges in crypto were unique to blockchain technologies or if they are common to all financial

crypto technology as the greatest reason for non-adoption. It was common for participants to report concern with the volatility and financial risk associated with cryptocurrencies, and either did not have or did not feel comfortable using extra funds to invest in it. Others (n = 10) still were distrustful and skeptical of crypto, due to its lack of regulation, security concerns, and perceptions of it being a fraudulent market. One participant encapsulated these fears, saying, "*without watchdogs and oversight, I believe the first to be taken advantage of are those of us with impairments or disabilities.*" Finally, some (n = 8) participants simply were not interested in crypto, or preferred other investment options. When asked what would make crypto technologies more desirable in the future, disabled non-adopters reported needing greater understanding of crypto technologies generally and assurance that crypto was accessible. Decreased financial risk, greater regulation and security, and more widespread use were also raised.

8 DISCUSSION

Our findings illustrate a wide variety of accessibility challenges for individuals with disabilities, especially vision impairments, when trying to access crypto technologies. We found substantial agreement between our audits of cryptocurrency exchanges and participant accounts of their cryptocurrency use. We found unlabeled and unreachable elements to be the most detrimental to crypto exchange use with AT, supporting many participant-reported difficulties with screen reader compatibility. Many accessibility violations were typical of accessibility violations across the web [5, 33], and reinforce the continued need for awareness in accessible web design.

Given how quickly we found catastrophic accessibility issues on the landing pages of Binance.us and Crypto.com, it was unsurprising that many disabled people found most exchanges inaccessible. Binance was the least accessible for users, as critical areas of site necessary for traversal and trading were not usable with AT. We found Coinbase.com to be the most accessible along its critical trading pathway, and this was supported by our participants who frequently referenced it as an exchange of choice. User reports also addressed several areas of concern which we could not assess in our audits, i.e., KYC verification, crypto storage and wallet accessibility, and troubleshooting strategies. KYC verification and crypto wallets created problems unique for disabled people, and reveal a lack of consideration for users with differential abilities in crypto technologies. Our results support previous findings in digital finance accessibility [25, 39, 43, 49]. It is clear that among digitized financial technologies, accessibility barriers continue to disallow disabled people access to growing areas of investment and ultimately independence over their finances. These accessibility challenges left many of our participants feeling frustrated, excluded, and dependent on others. Cryptocurrency technologies require many accessibility improvements before disabled users are able to exercise financial freedom equal to non-disabled users.

Non-adopters of crypto in our sample cited many commonly-reported barriers to crypto adoption among the general population, such as lack of knowledge in the domain, distrust of the technology and its processes, or financial risk [6, 7, 15, 17, 22, 35, 41, 45, 46]; however, these barriers were often exacerbated by the many accessibility concerns users expected to encounter. These expectations were likely a combination of crypto's reputation for poor usability and participants' poor experiences with other financial tools. No participants had experience with crypto technologies beyond cryptocurrency. Our findings signal a need to improve both accessibility and education in blockchain technologies in order to improve awareness of crypto and encourage adoption among disabled users.

8.1 Improving Crypto Accessibility

Our participants recommended improved compatibility with AT as a primary area for improvement, tackling the main areas of concern in our findings and across accessibility research [4, 14, 19, 20, 29, 32, 36]; however, some users noted that the best way to ensure accessibility is to involve those with disabilities in the development process. These reports are consistent with recommendations across accessibility research, but insights from the disabled community remain underutilized in practice [13]. Crypto and nascent technologies broadly should be keen to leverage the experiences of disabled users and ensure inclusivity in the development process. Inclusivity in crypto is of benefit not only to potential users with disabilities who may finally access an expanding financial sector, but also to the crypto industry itself, whose value, liquidity, and legitimacy rely on an ever-growing user base. If the goal of cryptocurrency is to decentralize and democratize finance, accessibility considerations should be fundamental to its development, ensuring that all users regardless of their abilities may access and utilize it to its fullest.

8.2 Limitations & Future Work

We note several limitations in our work. We relied on a questionnaire design which provided a focused but narrow view of participant experiences, as well as the auditor's judgment of accessibility severity as a non-disabled person. Future works in crypto accessibility should utilize data-rich study designs, such as interviews or workshops, to explore use through the perspective of disabled people. Regulations hindered our audits in the primary auditor's geographic area, and we could not test all aspects of cryptocurrency use. Replication of our study design in areas with less use restrictions would provide more complete and exhaustive audits of these technologies. Finally, we inspected only websites as they allowed for the use of automated accessibility tools to assist auditing. Future works should address accessibility in crypto mobile applications, as participants utilized them for all aspects of crypto ownership and may present their own unique challenges.

9 CONCLUSION

We have contributed a novel analysis of accessibility in emerging crypto technologies via an accessibility audit of top cryptocurrency exchanges and a questionnaire surveying disabled crypto users. Our audits found substantial and severe accessibility violations on each exchange which made them especially arduous to use with screen readers. Our participants reported a wide variety of accessibility concerns with crypto technologies which both supported and bolstered our audit findings. We have addressed implications for accessibility in crypto technologies and recommend improvements, as well as potential areas of future work in the domain.

REFERENCES

[1] 2022. https://www.coingecko.com/en/exchanges

[2] 2022. https://www.ibm.com/able/requirements/requirements/

[3] 2022. Cryptocurrency prices, charts and market capitalizations. https://coinmarketcap.com/

[4] 2022. Web Content Accessibility Guidelines (WCAG) 2.1. https://www.w3.org/TR/WCAG21/

[5] 2022. WebAIM: The WebAIM Million - An annual accessibility analysis of the top 1,000,000 home pages. https://webaim.org/projects/million/

[6] Abdulla Alshamsi and Prof. Peter Andras. 2019. User perception of Bitcoin usability and security across novice users. *International Journal of Human-Computer Studies* 126 (Jun 2019), 94–110. https://doi.org/10.1016/j.ijhcs.2019.02.004

[7] Mohammed AlShamsi, Mostafa Al-Emran, and Khaled Shaalan. 2022. A Systematic Review on Blockchain Adoption. *Applied Sciences* 12, 9 (2022), 4245.

[8] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative research in psychology* 3, 2 (2006), 77–101.

[9] Virginia Braun and Victoria Clarke. 2019. Reflecting on reflexive thematic analysis. *Qualitative research in sport, exercise and health* 11, 4 (2019), 589–597.

[10] Longbing Cao. 2022. Decentralized ai: Edge intelligence and smart blockchain, metaverse, web3, and desci. *IEEE Intelligent Systems* 37, 3 (2022), 6–19.

[11] Lin William Cong, Ke Tang, Yanxin Wang, and Xi Zhao. 2023. *Inclusion and democratization through web3 and defi? initial evidence from the ethereum ecosystem.* Technical Report. National Bureau of Economic Research.

[12] World Wide Web Consortium. 1997. World Wide Web Consortium Launches International Program Office for Web Accessibility Initiative. https://www.w3.org/Press/IPO-announce

[13] Sheri Byrne-Haber CPACC. 2019. The accessibility issue more people with disabilities should think about. https://sheribyrnehaber.medium.com/the-accessibility-issue-more-people-with-disabilities-should-think-about-7d9eae443da

[14] José-Manuel Díaz-Bossini and Lourdes Moreno. 2014. Accessibility to Mobile Interfaces for Older People. *Procedia Computer Science* 27 (Jan 2014), 57–66. https://doi.org/10.1016/j.procs.2014.02.008

[15] Michael Froehlich, Charlotte Kobiella, Albrecht Schmidt, and Florian Alt. 2021. Is it Better With Onboarding? Improving First-Time Cryptocurrency App Experiences. In *Designing Interactive Systems Conference 2021 (DIS '21)*. Association for Computing Machinery, 78–89. https://doi.org/10.1145/3461778.3462047

[16] Michael Fröhlich, Franz Waltenberger, Ludwig Trotter, Florian Alt, and Albrecht Schmidt. 2022. Blockchain and Cryptocurrency in Human Computer Interaction: A Systematic Literature Review and Research Agenda. *arXiv preprint arXiv:2204.10857* (2022).

[17] Hiroshi Fujiki. 2020. Who adopts crypto assets in Japan? Evidence from the 2019 financial literacy survey. *Journal of the Japanese and International Economies* 58 (2020), 101107.

[18] Hanna Halaburda, Guillaume Haeringer, Joshua Gans, and Neil Gandal. 2022. The microeconomics of cryptocurrencies. *Journal of Economic Literature* 60, 3 (2022), 971–1013.

[19] Simon Harper and Alex Q Chen. 2012. Web accessibility guidelines. *World Wide Web* 15, 1 (2012), 61–88.

[20] Simon Harper and Yeliz Yesilada. 2008. *Web accessibility: a foundation for research.* Springer.

[21] Christopher Henry, Kim Huynh, Gradon Nicholls, and Mitchell Nicholson. 2019. *2018 Bitcoin Omnibus Survey: Awareness and Usage.* Technical Report. Bank of Canada Staff Discussion Paper.

[22] Christopher S Henry, Kim P Huynh, and Gradon Nicholls. 2018. Bitcoin awareness and usage in Canada. *Journal of Digital Banking* 2, 4 (2018), 311–337.

[23] Christopher S Henry, Kim P Huynh, and Gradon Nicholls. 2019. Bitcoin awareness and usage in canada: An update. *The Journal of Investing* 28, 3 (2019), 21–31.

[24] Hyeji Jang, Sung H. Han, Ju Hwan Kim, and Kimin Kwon. 2021. Usability Evaluation for Cryptocurrency Exchange. In *Convergence of Ergonomics and Design*, Alma Maria Jennifer Gutierrez, Ravindra S. Goonetilleke, and Rex Aurellius C. Robielos (Eds.). Springer International Publishing, 192–196.

[25] Xiaofu Jin, Emily Kuang, and Mingming Fan. 2021. "Too old to bank digitally? ": A Survey of Banking Practices and Challenges Among Older Adults in China. In *Designing Interactive Systems Conference 2021*. ACM, 802–814. https://doi.org/10.1145/3461778.3462127

[26] Shaun K. Kane, Jessie A. Shulman, Timothy J. Shockley, and Richard E. Ladner. 2007. A web accessibility report card for top international university web sites. In *Proceedings of the 2007 international cross-disciplinary conference on Web accessibility (W4A) (W4A '07)*. Association for Computing Machinery, 148–156. https://doi.org/10.1145/1243441.1243472

[27] Irni Eliana Khairuddin, Corina Sas, Sarah Clinch, and Nigel Davies. 2016. Exploring Motivations for Bitcoin Technology Usage. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (San Jose, California, USA) *(CHI EA '16)*. Association for Computing Machinery, New York, NY, USA, 2872–2878. https://doi.org/10.1145/2851581.2892500

[28] Mitch Kramer. 2019. An overview of blockchain technology based on a study of public awareness. *Global Journal of Business Research* 13, 1 (2019), 83–91.

[29] Jonathan Lazar, Alfreda Dudley-Sponaugle, and Kisha-Dawn Greenidge. 2004. Improving web accessibility: a study of webmaster perceptions. *Computers in human behavior* 20, 2 (2004), 269–288.

[30] Junchen Li, Garreth W. Tigwell, and Kristen Shinohara. 2021. Accessibility of High-Fidelity Prototyping Tools. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 493, 17 pages. https://doi.org/10.1145/3411764.3445520

[31] Dave Murray-Rust, Chris Elsden, Bettina Nissen, Ella Tallyn, Larissa Pschetz, and Chris Speed. 2021. Blockchain and Beyond: Understanding Blockchains through Prototypes and Public Engagement. *ACM Transactions on Computer-Human Interaction* (Nov 2021). https://doi.org/10.1145/3503462 Just Accepted.

[32] Mike Paciello. 2000. *Web accessibility for people with disabilities.* Crc Press.

[33] Afra Pascual, Mireia Ribera, and Toni Granollers. 2014. Impact of web accessibility barriers on users with hearing impairment. In *Proceedings of the XV International Conference on Human Computer Interaction - Interacción '14*. ACM Press, 1–2. https://doi.org/10.1145/2662253.2662261

[34] Christopher Power, André Freire, Helen Petrie, and David Swallow. 2012. Guidelines are only half of the story: accessibility problems encountered by blind users on the web. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 433–442. https://doi.org/10.1145/2207676.2207736

[35] Muhammad Habib ur Rehman, Khaled Salah, Ernesto Damiani, and Davor Svetinovic. 2020. Trust in Blockchain Cryptocurrency Ecosystem. *IEEE Transactions on Engineering Management* 67, 4 (Nov 2020), 1196–1212. https://doi.org/10.1109/TEM.2019.2948861

[36] Richard Rutter, Patrick H Lauke, Cynthia Waddell, Jim Thatcher, Shawn Lawton Henry, Bruce Lawson, Andrew Kirkpatrick, Christian Heilmann, Michael R Burks, Bob Regan, et al. 2007. *Web accessibility: Web standards and regulatory compliance.* Apress.

[37] Corina Sas and Irni Eliana Khairuddin. 2015. Exploring trust in Bitcoin technology: a framework for HCI research. In *Proceedings of the Annual Meeting of the Australian Special Interest Group for Computer Human Interaction*. 338–342.

[38] Scott Schuh and Ozz Shy. 2016. US consumers' adoption and use of Bitcoin and other virtual currencies. In *DeNederlandsche bank, Conference entitled "Retail payments: mapping out the road ahead.*

[39] Osama Sohaib and Kyeong Kang. 2017. *E-Commerce Web Accessibility for People with Disabilities.* Lecture Notes in Information Systems and Organisation, Vol. 22. Springer International Publishing, 87–100. https://doi.org/10.1007/978-3-319-52593-8_6

[40] Fred Steinmetz, Marc von Meduna, Lennart Ante, and Ingo Fiedler. 2021. Ownership, uses and perceptions of cryptocurrency: Results from a population survey. *Technological Forecasting and Social Change* 173 (2021), 121073.

[41] Helmut Stix. 2021. Ownership and purchase intention of crypto-assets: survey results. *Empirica* 48, 1 (2021), 65–99.

[42] Melanie Swan. 2015. *Blockchain: Blueprint for a new economy.* " O'Reilly Media, Inc.".

[43] Hironobu Takagi, Shin Saito, Kentarou Fukuda, and Chieko Asakawa. 2007. Analysis of navigability of Web applications for improving blind usability. *ACM Transactions on Computer-Human Interaction* 14, 3 (Sep 2007), 13. https://doi.org/10.1145/1279700.1279703

[44] Markel Vigo, Justin Brown, and Vivienne Conway. 2013. Benchmarking web accessibility evaluation tools: measuring the harm of sole reliance on automated tests. In *Proceedings of the 10th International Cross-Disciplinary Conference on Web Accessibility - W4A '13*. ACM Press, 1. https://doi.org/10.1145/2461121.2461124

[45] Artemij Voskobojnikov, Svetlana Abramova, Konstantin Beznosov, and Rainer Böhme. 2021. Non-Adoption of Crypto-Assets: Exploring the Role of Trust, Self-Efficacy, and Risk. (2021).

[46] Artemij Voskobojnikov, Oliver Wiese, Masoud Mehrabi Koushki, Volker Roth, and Konstantin (Kosta) Beznosov. 2021. The U in Crypto Stands for Usable: An Empirical Study of User Experience with Mobile Cryptocurrency Wallets. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, 1–14. https://doi.org/10.1145/3411764.3445407

[47] Qin Wang, Rujia Li, Qi Wang, Shiping Chen, Mark Ryan, and Thomas Hardjono. 2022. Exploring web3 from the view of blockchain. *arXiv preprint arXiv:2206.08821* (2022).

[48] WebAIM. 2022. Wave Web Accessibility Evaluation Tools. https://wave.webaim.org/

[49] Brian Wentz, Dung Pham, Erin Feaser, Dylan Smith, James Smith, and Allison Wilson. 2019. Documenting the accessibility of 100 US bank and finance websites. *Universal Access in the Information Society* 18, 4 (Nov 2019), 871–880. https://doi.org/10.1007/s10209-018-0616-6

A APPENDIX

Table 1: A list of the guidelines we used in our accessibility audit to focus on perceivability

Checklist Item	Associated WCAG and/or IBM Guidelines
Check for alt-text on all non-decorative images.	WCAG 1.1 (A)
Check that all non-text content has an alternative presentation.	WCAG 1.1 (A)
Check for captioning on prerecorded audio/video content.	WCAG 1.2 (A)
Check for captioning for live content.	WCAG 1.2 (AA)
Check for an audio description of video content.	WCAG 1.2 (AA)
Check for sign language support for videos/audio content.	WCAG 1.2 (AAA)
Check if all elements are arranged in a meaningful order.	WCAG 1.3.2 (A)
Check if information is conveyed solely through color.	WCAG 1.4.1 (A)
Check for audio controls on automatic video/audio content that plays for more than 3 seconds.	WCAG 1.4.2 (A)
Check if color contrast of elements and background is at least 4.5:1 (preferably 7:1 [AAA]) via color picker.	WCAG 1.4.3 (AA)
Check text size is at least larger than approximately 16px or can be zoomed into 200%.	WCAG 1.4.4 (AA)

Table 2: A list of the guidelines we used in our accessibility audit to focus on operability

Checklist Item	Associated WCAG and/or IBM Guidelines
Test if GUI is navigable with keyboard arrow keys.	WCAG 2.1 (A)
Test if GUI elements can be invoked with enter/spacebar.	WCAG 2.1 (A)
Test if GUI interactions can be revoked with escape.	WCAG 2.1 (A)
Check for any keyboard traps.	WCAG 2.1.2 (A)
Check for keyboard shortcuts which require use of letter, number, or punctuation keys. Do they utilize non-print keys (ctrl, alt, etc.) and can they be remapped?	WCAG 2.1.4 (A)
Check for time limits on content. Do users get enough time to reasonably access content? Can users alter/remove time limits?	WCAG 2.2.1 (A)
Check if blinking, scrolling, or auto-updating content can be paused, stopped, or hidden unless essential for function.	WCAG 2.2.2 (A)
Check if timing is essential anywhere.	WCAG 2.2.3 (AAA)
Check if interruptions can be suppressed or postponed, except in emergencies.	WCAG 2.2.4 (AAA)
Check if anything flashes more than 3 times in a row in any one second period.	WCAG 2.3 (A)
Check if repeated blocks of content can be bypassed.	WCAG 2.4.1 (A)
Is all functionality maintained via keyboard, without requiring specific timings for keystrokes?	WCAG 2.4.2 (AAA)
Is the page properly titled?	WCAG 2.4.2 (A)
Are content headings properly labeled?	WCAG 2.4.2 (AA)
Are page sections labeled?	WCAG 2.4.2 (AAA)
For tables, does screen reader read name, description, row, and column headings when appropriate?	IBM 502.3.3
Can the page be navigated sequentially and in an order which preserves meaning?	WCAG 2.4.3 (A)
Can the purpose of a link be determined from its text alone or link context?	WCAG 2.4.4 (A)
Is there a keyboard focus indicator available when using only the keyboard?	WCAG 2.4.7 (AA)

Table 3: A list of the guidelines we used in our accessibility audit to focus on understandability

Checklist Item	Associated WCAG and/or IBM Guidelines
Do interactions work as expected based on their appearance/labeling?	WCAG 3.2 (A)
Does the in-app context change based on the current focus or user input without warning/explanation?	WCAG 3.2 (A)
Does the application provide error recognition and recovery options?	WCAG 3.3 (A)
Do error messages speak the user's language?	WCAG 3.3 (A)
Are these error messages perceivable while using a screen reader?	WCAG 3.3 (A)
Do they provide solutions or useful suggestions for recovery?	WCAG 3.3.1 (A)
Are forms are labeled?	WCAG 3.3.2 (A)
Do forms maintain user information?	WCAG 3.3.2 (A)
Does the application ask for confirmation after financial transactions?*	WCAG 3.3.4 (AA)
Does the application/site allow for correction/reversal during financial transactions?*	WCAG 3.3.4 (AA)

*Could not be assessed in the auditor's region.

Table 4: A list of the guidelines we used in our accessibility audit to focus on robustness

Checklist Item	Associated WCAG and/or IBM Guidelines
Does the software allow user control over platform accessibility features?	IBM 502.2.1
Check for user control of text size/font.	IBM 502.2.1
Check for user control of color.	IBM 502.2.1
Check for user control of element sizes.	IBM 502.2.1
Check for alternatives to gestural controls.	IBM 502.2.1
Does the application disrupt any platform accessibility features?	IBM 502.2.2
Can page language be programmatically determined?	WCAG 4.1.1 (A)
Test if all UI components/object names, state, control type, actions, and instructions can be programmatically determined by navigating through application.	WCAG 4.1.2 (A) IBM 502.3.1
Any current values or range of possible values is programmatically determinable.	IBM 502.3.4
Are status messages programmatically determinable such that they can be perceived via assistive technologies without receiving focus?	WCAG 4.1.3 (AAA)

Table 5: Critical accessibility violations in site landing pages

Exchange	Violated Guidelines (Severity)	Issues Found	Implications for Users
Binance	WCAG 2.1.1 (A) - Keyboard	Trade and Resources links in header were unreachable with keyboard-only use.	Keyboard-only or screen reader users cannot reach the trading or resources pages through the site's main navigation.
Binance	IBM 502.3.3 - For tables, screen reader reads name, description, row, and column names.	A table presenting the prices of highly-traded cryptocurrencies could not be understood using a screen reader as row labels could not be read.	Screen reader users may have difficulty understanding what prices are associated with which currencies in the table.
Coinbase	WCAG 2.4.7 - Keyboard Focus Indicator	Sign-in/sign-up buttons lacked a focus indicator for during keyboard-only use.	Keyboard-only users would have difficulty knowing if they have reached their sign-in/sign-up buttons in the header, impeding their ability to access or create accounts.
Crypto.com	WCAG 2.1.2 (A) - No Keyboard Trap	There was a keyboard trap on the NFT link in the header of the landing page.	Keyboard-only and screen reader users were blocked from accessing much of the header and subsequent landing page without reloading the page and avoiding the link.
Crypto.com	WCAG 2.4.3 (A) - Focus Order	Mobile hamburger menu was skipped over and unreachable when using a screen reader.	Mobile screen reader users would have great difficulty navigating the Crypto.com site as the main navigation is inaccessible.
Crypto.com	WCAG 1.2.1 (A) - Alternatives for Audio/Video	No captions or text description were presented for an auto-playing, soundless commercial that gives the appearance of people talking.	Though it serves as a decorative background, it would benefit DHH users to provide a caption clarifying it has no sound.
Kraken	WCAG 1.2.1 (A) - Alternatives for Audio/Video	No captions or text description were presented for an auto-playing, soundless video that shows trading through their app.	To remove ambiguity for DHH users, it would be helpful to clarify there is no sound or voiceover.

Table 6: Critical Accessibility Violations in Sign-Up Task

Exchange	Violated Guidelines (Severity)	Issues Found	Implications for Users
Binance	WCAG 4.1.2 (A) & IBM 502.3.1 - Programmatically Determinable Elements	All elements on Binance's sign-up form were unlabeled.	Screen reader users would not know what information to input in each form box, making account creation nearly impossible without help.
Coinbase	WCAG 3.3.1 (A) - Error Identification	Error messages were provided during sign-up but were not perceivable with a screen reader.	Screen reader users would have difficulty knowing if they have made a mistake in their inputs for signing up as they could not be read by a screen reader.
Kraken	WCAG 4.1.2 (A) & IBM 502.3.1 - Programmatically Determinable Elements	The dropdown menu for selecting the user's location could not be traversed with a screen reader.	Screen reader users would be unable to provide their location during sign-up, making it impossible create an account without assistance.

Table 7: Critical Accessibility Violations in Trading Task

Exchange	Violated Guidelines (Severity)	Issues Found	Implications for Users
Binance	WCAG 2.1.1 (A) - Keyboard	Areas of the header, i.e., Trade, Resources, Notifications, and Profile, and cryptocurrency price trend graphs were all unreachable using keyboard-only or screen reader.	Keyboard-only or screen reader users would continue to have difficulty utilizing the site navigation and be unable to effectively read the crypto market without assistance.
Binance	WCAG 4.1.2 (A) & IBM 502.3.1 - Programmatically Determinable Elements	Elements necessary to purchase or sell cryptocurrencies were unlabeled.	Screen reader users would have great difficulty knowing where to input information necessary to trade, and may have accidental transactions.
Kraken	WCAG 2.4.4 (A) - Link Context	Home and social media links were not named.	Though not essential to trading, poor link labeling may create ambiguity for navigating during screen reader use.