Don't Stop Me Now! Exploring Challenges Of First-Time Cryptocurrency Users

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ABSTRACT

Cryptocurrencies have increasingly gained interest in practice and research alike. Current research in the HCI community predominantly focuses on understanding the behavior of existing cryptocurrency users. Little attention has been given to early users and the challenges they encounter. However, understanding how interfaces of cryptocurrency systems support, impede, or even prevent adoption through new users is essential to develop better, more inclusive solutions. To close this gap, we conducted a user study (n=34) exploring challenges first-time cryptocurrency users face. Our analysis reveals that even popular wallets are not designed for novice users' needs, stopping them when they would be ready to engage with the technology. We identify multiple challenges ranging from general user interface issues to finance and cryptocurrency-specific ones. We argue that these challenges can and should be addressed by the HCI community and present implications for building better cryptocurrency systems for novice users.

CCS CONCEPTS

• **Human-centered computing** → *Empirical studies in HCI*; • **Security and privacy** → *Usability in security and privacy*; • **Applied computing** → **Digital cash**.

KEYWORDS

cryptocurrency, blockchain, first-time users

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1 INTRODUCTION

Driven by the rising popularity of cryptocurrencies, blockchain technology is receiving increased interest from practitioners and researchers. By January 2021, the number of Bitcoin wallet users has grown to exceed 65 million [10]. Over 8300 cryptocurrencies with a market capitalization exceeding 1 trillion USD are tracked on CoinMarketCap[1]. Accounting for 635 billion USD [9], Bitcoin [32] indisputably remains the most popular cryptocurrency.

Beyond cryptocurrencies, there is considerable ongoing development to improve blockchain technology. Advocates view the technology as transformative, comparing its potential impact to the Internet [11] and going as far as discussing a decentralized digital society [45]. At the same time, cryptocurrency systems still face major unsolved challenges: user interfaces suffer from usability issues [5, 12, 15, 18, 27], there remain fundamental trust challenges [4, 17, 22, 41, 42], cryptocurrencies are complex to understand [11, 12] and have a high entry barrier for people with less technical knowledge [19]. The HCI community has started to address these challenges — Elsden et al. presented the first topology of blockchain applications in the context of HCI and argue for an active role of HCI in the domain [11]. However, research has missed taking a closer look at novice cryptocurrency users, predominantly focusing on users already acquainted with the technology.

This leaves a gap in understanding what challenges novice users face. What barriers need to be overcome between the decision to buy cryptocurrency and making use of it for the first time? Understanding how interfaces of current cryptocurrency systems support, impede, or even prevent the adoption through new users is essential to develop better, more inclusive solutions in the future. To address this, we have conducted a qualitative user study with 34 participants. In a think-aloud study, we recorded participants during three tasks, each essential for new users: account registration, the first acquisition of Bitcoin, and spending them in an online shop. We triangulate our observations with semi-structured interviews with all participants. Contrary to previous research, our study focuses on custodial wallets, being the likely entry point for users without technical understanding of blockchain technology. Doing so, our study complements previous work investigating key management challenges [1, 12, 15].

Our analysis identified multiple challenges novice users need to overcome. We present three categories: (1) general user interface challenges; (2) finance-related challenges; and (3) cryptocurrency

[1]https://coinmarketcap.com/ (last accessed 15.05.2021)

challenges. Surprisingly, most challenges are not rooted in technical constraints of blockchain technology and can, therefore, be addressed with HCI methods. We discuss why the considered wallets are not designed with novice users in mind and present implications for HCI researchers and practitioners on how to address open challenges, to ultimately build systems better equipped to address the needs of novice users.

Contribution Statement. The main contributions of this work are (1) a qualitative investigation (n=34) of how first-time users interact with cryptocurrencies; (2) a classification of challenges users face in the process; and (3) implications for building cryptocurrency systems for novice users.

2 BACKGROUND

Our work builds on several strands of research, most notably research on blockchain and cryptocurrency applications from an HCI perspective.

2.1 Cryptocurrencies and HCI

Since the inception of Bitcoin in 2008 as "Peer-to-Peer Electronic Cash System" [32], cryptocurrencies have seen increasing rates of adoption, with recent studies reporting rates as high as 11% in Germany [8] and 18% in Turkey [39]. Likewise, cryptocurrencies have become a topic of interest in the HCI community.

Elsden et al. review existing research on blockchain applications and highlight that many of the core conceptual challenges related to long-standing issues in HCI research. They call on the HCI community to investigate the fundamental human challenges connected to blockchain technology [11]. Several publications have explored motivations of cryptocurrency users [15, 18, 23, 27, 41] with Financial Interest, Ideological Interest or Technological Interest [15] emerging as main reasons to engage with the technology. Users perceive cryptocurrencies to fulfill all functions of money [30], would like to use them as a means of payment, but criticize the lack of opportunity to do so [15].

Furthermore, previous work shows that the usability of cryptocurrency applications remains problematic [2, 5, 12, 15, 18, 27, 31]. Cryptocurrencies are difficult to understand and misconceptions are common. Mai et al. explored mental models of both cryptocurrency users and non-users and identified misconceptions in regard to keys, fees, and anonymity [29]. These misconceptions increase the risk of user errors: Krombholz et al. presented the first quantitative study of cryptocurrency users (n=990) and reported that 22.5% had lost cryptocurrencies in the past, most commonly through self-induced errors. Industry reports confirm these findings: In 2018, 18% of cryptocurrency users reported having lost cryptocurrencies due to user errors [13]. Security practices, especially key management, have been identified as core usability issues by past research [12, 15, 26, 29]. Eskandari et al. presented a first look at key management, remarking that users are challenged to keep keys simultaneously resilient to loss, resistant to digital theft, and accessible [12]. Krombholz et al. suggest categorizing wallets based on the control over key management they offer [27]. In their DIS'20 paper Froehlich et al. distinguish between self-managed and custodial wallets – wallets that hide key management aspects from the user, but require trust in the intermediary — and highlight the latter as an alternative for users with less technical affinity. They argue that users' decisions to choose a custodial or self-managed wallet is implicitly mediated by their risk assessment. Users less knowledgeable and motivated in their security skills would be inclined to choose custodial wallets over self-managed ones because they perceive the risk of making a mistake themselves higher than the risk of suffering betrayal from a third party [15].

With a considerable amount of users engaging with custodial wallets[2] and the apparent benefit of a lower technical entry barrier to foster financial inclusion, we were surprised to not find any HCI studies (beyond a Kazerani et al. with two participants [21]) focusing on custodial wallets. We think this gap is worth addressing. Recent work by Huebner et al. suggests cryptocurrency applications suffer from issues beyond key management. Their analysis of over 300.000 app store reviews revealed that both "user interfaces" and "the signup experience" of blockchain apps are rated worse than those of comparable finance applications [20].

2.2 Novice Users

While the importance of understanding novice users' needs is well established in the HCI community [33, 35], there seems to be no universally agreed-on definition. For the scope of this paper, we, therefore, refer to novice users as *"users who previously have not interacted or owned cryptocurrencies"*. While previous research in the field of cryptocurrencies to date has focused predominantly on established users, there is a small but emerging body of work investigating novice users [2, 16, 18, 21, 31].

Early work by Gao et al. characterizing the perception of Bitcoin across users and non-users with an interview study found that non-users expected that they would not be able to use cryptocurrencies without understanding the technology [18]. Kazerani et al. presented an exploratory study investigating the usability of Bitcoin with two novice users at the example of ChangeTip and Coinbase. Despite having just two participants, their study is worth mentioning, because they are, to our knowledge, the first to provide qualitative evidence that custodial wallets are hard to use [21]. More recently, Moniruzzaman et al. performed a cognitive walkthrough of five self-managed cryptocurrency wallets with five experts "*simulating the evaluation from the eye of a novice user*". They compare desktop and mobile wallets of different cryptocurrencies (Bitcoin, Ethereum, Ripple) and find high variations in error rates between different apps, overall concluding that current wallets lack usability for novice users [31].

Alshamsi and Andras presented the most comprehensive approach to date and were the first to include novice users directly. They quantitatively compared the perceived usability and security between Bitcoin and credit/debit cards with an in-between study setup with 22 novice cryptocurrency users and 33 established credit/debit card users. They report significantly worse perceptions of Bitcoin along the dimensions of Learnability, Efficiency, Help, Security, and Satisfaction. They highlight the relation between perceived usability and perceived security, arguing that the good usability of credit/debit cards positively influenced security

[2] Coinbase self-reports 43 million users (Jan 2021). See https://www.coinbase.com/about (last accessed 15.05.2021)

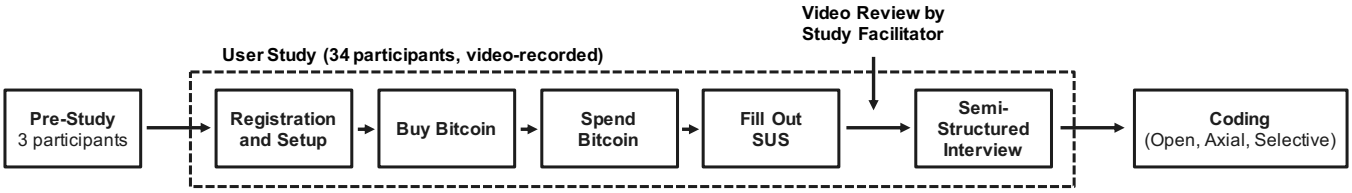

Figure 1: A visualization of our research approach. The user study was comprised of three tasks (1) Registration and Setup, (2) Buying Bitcoin, and (3) Spending Bitcoin. Afterward, participants were interviewed using retrospective probing. Data analysis followed an inductive approach, coding over several rounds.

perception. In contrast, Bitcoin's comparably poorer usability negatively influenced its security perception. Based on their findings, they discuss tradeoffs between usability and security and provide first suggestions on how to improve user interfaces for cryptocurrency systems. They conclude that Bitcoin as a payment system still faces major challenges and call for research on educating users, understanding users' challenges and mental models, and exploring how usable interfaces for novices can be designed [2]. With their findings rooted in a quantitative comparison study between one self-managed cryptocurrency app and credit card usage, we complement their work by contributing a qualitative think-out-aloud study providing the first in-depth exploration of novice users' challenges across three representative wallets on both mobile and desktop devices.

2.3 Summary

In the context of this paper, we can build on several learnings from previous work. Cryptocurrencies are complex to understand and misconceptions between users' mental models and the actual technical workings of the systems are common. Key management has been recognized as a challenge for users and addressed extensively by previous research. Custodial wallets offer an option to engage with cryptocurrencies without dealing with the details of key management, however, they require trust in the intermediary. While already widely used, we lack research on challenges users face with custodial wallets. First work exploring novice users' usability perception of Bitcoin indicates the need for further research. This work addresses these open questions and takes a closer look at the challenges that first-time cryptocurrency users are confronted with and how to overcome them.

3 METHOD

In this section, we describe our research approach, the sample of participants, the setup of the user study, and the analysis process.

3.1 Approach

We conducted a user study in English language between May 16th and September 9th, 2020, lasting between 12 and 102 minutes per participant (total 1195 minutes, average 39 minutes). Due to COVID-19, the user study was conducted remotely. Participants were instructed to think aloud and record their screens and audio — if necessary they received help setting up the recording software. After completing the study, users rated the usability of the tested wallets and shared their experiences in an interview. Prior to the study, we pre-tested our approach (n=3), resulting in minor adjustments of the instructions. As sensitive personal information had to be entered during registration, we obtained approval from the ethics board of our university (ID: EK-MIS-2020-018). Participants received EUR 30 or equivalent as compensation.

3.2 Participants

We recruited 34 people via social media and local networks in Munich, Germany. Participants qualified if they expressed interest to own cryptocurrency and reported not having done so in the past. 44 people indicated initial interest, of which 41 qualified. 6 people withdrew before starting and one participant from South Africa could not properly use the tested apps due to geographical restrictions. All participants resided in Europe – Germany (22), Austria (5), Denmark (2), Romania (2), Portugal (1), Sweden (1), United Kingdom (1). In the following, only the remaining 34 participants who started the user study are considered. 31 of them finished the entire study, resulting in a completion rate of 91%.

Table 1: The participants' demographics (n=34). The sample shows a slightly above average ATI scores, equal distribution between genders, is relatively young and well educated.

Demographic	Participants (%)
Gender	
Male	17 (50%)
Female	17 (50%)
Age	
20 – 24	5 (15%)
25 – 29	22 (65%)
30 – 39	4 (12%)
40 – 49	0 (0%)
50 – 59	3 (9%)
Highest Completed Education	
High School	5 (15%)
Bachelor Degree	14 (41%)
Master Degree	14 (41%)
PHD or Higher	1 (3%)
Annual Household Income in EUR	
15k or less	12 (35%)
15k – 30k	10 (29%)
30k – 45k	4 (12%)
45k – 60k	4 (12%)
60k or more	4 (12%)
ATI Scale	
1 – 1.99	1 (3%)
2 – 2.99	4 (12%)
3 – 3.99	11 (32%)
4 – 4.99	16 (47%)
5 – 6	2 (6%)

Table 1 shows the demographics of the participants. Our sample is gender-balanced with an average age of 28.73 years and an average annual household income between EUR 25,294 and EUR 49,411. In comparison, previous quantitative work found the sample of cryptocurrency users to be predominantly male (85%) with an average age of 28.56 years [27]. As for household income, we could not identify comparable data, but think it is worth to be reported in the context of cryptocurrencies. The Affinity for Technology Interaction (ATI) score describes a person's tendency to engage in or avoid technology interaction (6=high affinity, 1=low affinity). Our participants rank between 1.78 and 5.56 (mean 3.89) showing a broad range among the sample, slightly above average compared to the German population [3, 14, 47].

With women arguably making up half the potential user group, we think it is important not to marginalize them in the investigation of usability issues. We did not notice any gender differences during our study and are confident that our findings are representative of first-time cryptocurrency users.

3.3 Apparatus

The user study explored the challenges first-time users face when first interacting with cryptocurrencies. To reduce tool bias, we selected three wallets: Bitpanda[3], Coinbase[4], and TenX[5].

The wallets were chosen because they met several selection criteria: They were (1) custodial wallets, (2) implemented features to buy and send cryptocurrency, (3) offered both iOS and Android clients, and (4) had positive app store ratings (see table 2). Only Bitpanda and Coinbase offered a web application for desktop devices. Figure **??** shows the main screen of the tested wallets.

We reasoned that in a natural situation users would decide on whether to register an account on a mobile or desktop device. We, therefore, kept the decision which form factor to use to the participants and randomly assigned them to one of the three wallets according to their choice[6].

Table 2: The mobile app ratings (August 24th 2020) and the number of participants per wallet completing the study.

Wallet	Ratings (1=worst, 5=best)		Participants	
	App Store	Play Store	Mobile	Desktop
BitPanda	4.4	4.5	6	7
Coinbase	4.5	3.7	6	6
TenX	4.4	4.5	6	-

The user study was composed of three tasks, structured around the activities of (1) creating an account, (2) purchasing cryptocurrency, and (3) spending cryptocurrency. We chose these tasks because they arguably represent the first steps users want to take when engaging with a cryptocurrency wallet for the first time. Previous work investigating self-managed wallets used similar tasks [2, 31], but did not include purchasing of cryptocurrencies.

We deliberately kept the task instructions to a minimum to allow participants to explore the wallet functionality themselves but advised them to ask for help if they got stuck. 16 out of 34 participants requested help at least once during the study. 3 out of 34 participants canceled the study (no common pattern). Each participant was instructed to

(1) Setup an account with the select application
(2) Purchase Bitcoin worth EUR 20
(3) Spend a maximum of EUR 15 in Bitcoin for a gift card or donation using Bitrefill[7] or BitPay[8]

After completion of all tasks, participants filled out a questionnaire to rate the usability of the tested wallets using the System Usability Scale (SUS) [7]. At last, an interview was conducted remotely via WhereBy[9] and recorded with the consent of participants. During the interview, challenging situations identified in the video recordings were addressed using retrospective probing [6].

3.4 Data Analysis

Data analysis followed an inductive approach using the think aloud and interview transcripts as data sets. To obtain an initial understanding, we used open and axial coding. During the initial open coding, two researchers independently coded the first 15 protocols. In a second step, we discussed the emerged codes and their relations to categorize them into higher-level axial codes. After agreeing on a final set of categories, focusing on challenges users encounter, two researchers used the agreed-upon codebook to selectively code the data set of the first 10 participants. We report an inter-rater reliability with an average Krippendorff's alpha of 0.87, indicating a high degree of agreement between coders [25].

Table 3: The inter-rater reliability (Krippendorff's Alpha) for the first 10 interviews.

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
0,96	0,90	0,94	0,82	1,00	0,96	0,90	0,78	0,68	0,72

Table 3 shows Krippendorff's alpha broken down to the participants' levels. Conflicts between coders occurred mostly due to ambiguous statements — i.e. statements that addressed several issues at once — and could be resolved in a joint review. The remaining interviews were coded by only one of the two researchers.

3.5 Limitations

We recognize that this study setup faces limitations regarding the generalizability of the results. First, the three selected wallets might not be entirely representative for all custodial wallets. By choosing well-rated ones, we reason that these applications are comparably well suited to identify challenges related to cryptocurrencies and not app design in general. Second, the think-aloud method puts participants in an unusual situation, potentially influencing behavior, and cannot capture issues users are not aware of [37]. We address this through method-triangulation with retrospective probing [6]. Third, all participants of the study were situated in Europe. Different cryptocurrency regulations in other jurisdictions might impact the experience of users in ways not observed.

[3] http://bitpanda.com/ (last accessed 15.05.2021)
[4] https://coinbase.com/ (last accessed 15.05.2021)
[5] https://tenx.tech/ (last accessed 15.05.2021)
[6] We included both desktop and mobile devices to identify overarching challenges when engaging with cryptocurrencies. We acknowledge that desktop and mobile devices are different form-factors that deserve independent examination in future research.
[7] https://bitrefill.com/ (last accessed 15.05.2021)
[8] https://bitpay.com/ (last accessed 15.05.2021)
[9] https://whereby.com/ (last accessed 15.05.2021)

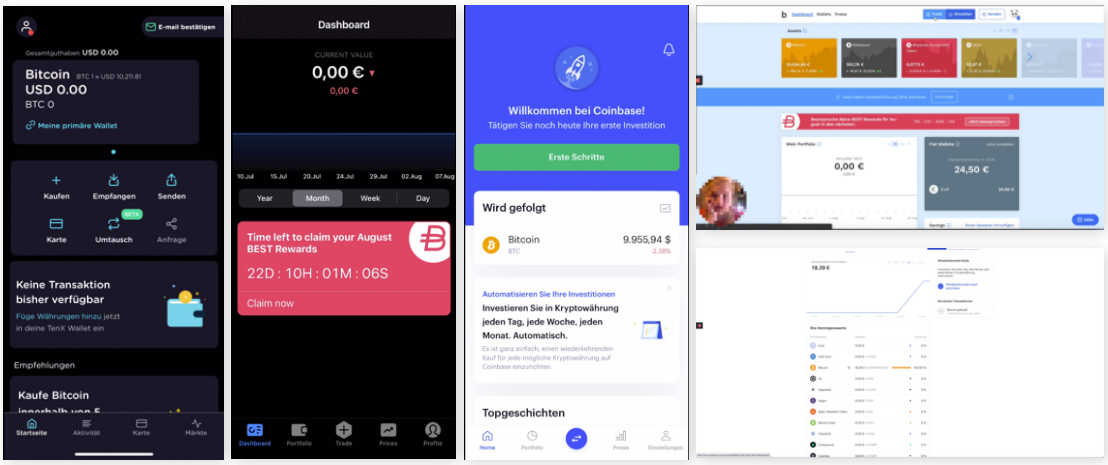

Figure 2: Screenshots of the first screen of each of the tested wallets (a full set of screenshots can be found in the supplementary material). From Left to right: TenX Mobile, BitPanda Mobile, Coinbase Mobile, Bitpanda Web, Coinbase Web.

4 FINDINGS

Our analysis reveals several challenges novice users have to overcome when interacting with cryptocurrency systems. The collected SUS ratings confirm these observations, showing that participants did not perceive the wallets to be usable. Table 4 depicts the scores and their corresponding US letter grades (A+ to F) [43] for both mobile and desktop versions. With the exception of TenX[10], the wallets rated well below the overall average SUS score in general (68) [43], the average SUS score of mass-market consumer software (74) [28], and the average SUS score for mobile apps (77) [24]. With a SUS score of 80 being the industrial goal [28], the perceived usability of the tested apps lacks considerably for novice users — emphasizing the need to further examine the usability of wallet applications.

Table 4: The resulting SUS scores per wallet. In parentheses the corresponding letter grades are shown.

Wallet	Ratings (max 100.0)	
	Mobile	Desktop
BitPanda	49.6 (F)	51.3 (F)
Coinbase	48.0 (F)	55.8 (D)
TenX	70.0 (C)	-

We organize the identified challenges into three overarching categories. Challenges in the first two categories are not exclusive to cryptocurrencies but relevant for developing a complete understanding of why users are struggling with custodial wallets today. Our intention behind reporting these challenges is to provide guidance for practitioners on how to address them.

(1) **User Interface Challenges:** This category subsumes challenges originating from the design of the user interface.
(2) **Finance Challenges:** This category subsumes challenges connected to the financial services offered in the application.
(3) **Cryptocurrency Challenges:** This category subsumes challenges tightly linked to core cryptocurrency concepts.

[10]While we cannot provide a definite answer to the comparably better SUS of TenX, we reason that the mobile-first design approach led to a simpler user-interface, more suited for novice users.

4.1 User Interface Challenges

We observed a set of common usability issues resulting from poor interface design across all three wallets. These findings may shed light on why user interfaces of blockchain mobile apps were found to be perceived worse than other categories of finance apps [20].

4.1.1 User Interfaces Are Not Optimized For Novice Users. User Interfaces offer rich functionality, overloading new users with information without adequately emphasizing the primary actions the user is looking for. At the same time the system status is only poorly reflected in the user interface and critical information for new users – i.e. account verification status — is hidden in setting menus.

Ambiguous System Status. To interact with a system, users generally need to answer two questions: (1) "What is the state of the system?", and (2) "How can they change it?" [48]. Users struggled to understand the system status in two situations specifically: the account verification status and which features were accessible. Especially the out-of-sync account verification status resulted in a cumbersome experience for users. Unclear about whether the verification was initiated, some users started the process a second time, even though their documents were already being processed. In several instances, users needed to manually sign out and in of their accounts for the new status to take effect, even after receiving an email confirmation about the success of the verification. In two wallets, unverified users could access the main interface of the application, without having the necessary authorization to interact with it. Instead, interactions resulted in error messages, often shown only after a few steps into the interaction.

Primary Actions Are Difficult to Access. Users opening a cryptocurrency application for the first time have a limited set of actions they want to complete: Finish their account setup, purchase cryptocurrency and potentially send a first transaction. All wallets had feature-rich user interfaces with high information density, designed for advanced users. Novice users, however, struggled to make sense of the information, find orientation, and locate the features they

needed. The most striking example of this was the account verification. Being an essential step it should be easily accessible. Instead, two wallets placed it in the settings menu, leaving users clueless where to find it. Another complicating issue concerned the purchasing flow to cryptocurrencies. One wallet required an intermediary step to deposit money into a "Euro Wallet" before users could buy cryptocurrency; directly purchasing cryptocurrency was not possible. This interim step increased interaction cost and consistently startled users — they tried to buy Bitcoin first until, by trial-and-error, they figured out they have to deposit Euros first.

4.1.2 General Issues. We encountered several additional usability issues during the study. Many of these are specific to the interface design of single wallets – e.g. unlabeled buttons or ambiguous iconography. We think that two issues are worth mentioning as they occurred across all three wallets.

Poor Error Messages. Novice users, likely to make mistakes during the initial exploration, are dependent on error messages that support their learning. However, participants were consistently confronted with error messages failing to do so: they were poorly constructed, contained finance-related or technical terms, and lacked actionable advice to support recovery. Application of established guidelines, namely that error messages should be explicit, human-readable, polite, precise, and contain constructive advice, could greatly benefit the experience of novice users [36].

Localization Issues. All three wallets exhibited a lack of localization, specifically poor, partial, or no translation at all. Additionally, one wallet did not accept the non-ascii character in the registration form, resulting in P15 having to find a workaround for the character "ß" in their name. While all participants in our sample were proficient in English, many people around the world are not, seriously limiting accessibility for those. For users struggling to learn the vocabulary that comes with cryptocurrencies inaccurate and faulty translations may further hinder their progress. Beyond accessibility, developers should provide professional localization out of self-interest. Users that encountered poor or partial translations noted the "*unprofessional*" impressions it left on them.

4.2 Finance Challenges

Our analysis revealed several finance-related challenges. These challenges arise from aspects every finance app needs to deal with. We found that the verification process is a major cause of frustration for first-time users and payment methods — though essential for cryptocurrency apps — frequently do not work as expected.

4.2.1 The Extended Account Verification Introduces Friction. Regulations require financial institutions to verify the identity of their customers. We observed the extended verification process to be one of the major causes for errors and frustration of participants during the study, confirming earlier findings [20].

Inadequate Explanations: The extended verification process is most commonly denoted as "Account Verification" and covers two aspects: anti-money-laundering (AML) and know-your-customer (KYC) regulations. The latter requires users to disclose the real identity, including personal information such as their national ID and address of residency. However, the necessity behind this process is only sparsely explained to users, often with rather technical and sparse descriptions, e.g. "Due to anti-money laundering policies". More detailed information provided behind a link is ignored by the vast majority of users. This results in misconceptions and negative sentiment on the users' side. For example, P12 assumed the data was collected for "*customer research and profiling*". P20 felt anxious about providing such personal data "*Does one really need to enter all this information ... This is scary*" and P27 thought the wallet expected them to "*be a fraudster*". In comparison, users with knowledge about the purpose of this extended verification process — e.g. through experience with other finance or ride-sharing apps — accepted the process and did not further question it.

Weak KYC Framework Integration: For identity verification, all wallets used third-party providers. Weakly integrated provider frameworks, as we observed in one wallet, break with the familiarity of the app and interrupt the overall user experience. Participants were confused by the new interface, increasingly so when different KYC providers were selected, seemingly at random, when the process was restarted. For example, P19 assumed to be the victim of a scam: "*It was a different one than the first time. I thought, "Oh my god, somebody hacked it and now he is taking all my information!"*. The weak integration was additionally frustrating for users who had to restart the process as it did not retain the state of already submitted documents.

Error-Prone KYC Process: This proved especially relevant, as KYC processes were likely to fail. 14 participants had to restart the verification process at least once, resulting in frustration: P21 vented, "*This is real crap!*" and P27 complained, "*I am going crazy with this!*". There were several issues leading to cancellation:

- **Policy Issues:** Policy issues arise from rules the wallet and KYC provider agreed on. For example, some types of national IDs were not accepted. In another instance, P19 registered their wallet account with only the first section of their hyphenated name, which was not accepted by the KYC provider and could only be changed by contacting the customer support of the wallet.
- **Document Issues:** Several users started the verification before preparing all documents and subsequently had to cancel it. While IDs were generally available, several users had to look for a utility bill to confirm their address.
- **Submission Issues:** In some instances, users had their documents not in the right format for the device they were using. P7 exported a PDF utility bill from an app on his smartphone, but could not select a PDF on the mobile interface. After several attempts, the participant sent the PDF to his computer, printed it, and scanned the printout using the camera dialogue of the verification process. Similarly, users on desktop devices had to switch to their smartphones to scan their IDs.
- **Connection Issues:** We observed several users struggling with network connection issues — either the KYC process would not start or abort abruptly.
- **Technical Issues:** Finally, we saw a variety of different technical issues, ranging from camera issues to browser compatibility issues to generic error messages.

4.2.2 Payment Methods Introduce Friction. Payment methods were an additional source of frustration for participants. We observed several underlying reasons: first, some users are anxious because they deal with money; second, payment methods used to buy Bitcoin did not work; and third, the status of the deposited money was not clearly communicated to users right away.

Dealing With Money Makes Users Nervous: We observed that some participants were increasingly cautious and nervous because they were dealing with money. While a soft observation, we think this is relevant as it indicates that some users might interact quite differently with finance-related systems compared to other categories. P20 stated "*With money, I am always extra cautious*" and P8 expressed clear expectations "*This is about money, not buttons!*". Consequently, users are anxious about making mistakes, especially given that they are not used to the interface of the new application. P4 expressed this insecurity when checking transaction details multiple times before finally submitting, saying "*It seemed like an important button that might initiate a transaction. I was unsure about what would happen if I entered a too high amount.*".

Payment Methods Are Likely To Fail: While essential to a cryptocurrency, payment methods proved challenging for many users — 10 participants needed to initiate the payment process at least twice. Several participants explicitly expressed disappointment that they could not pay via PayPal; most other participants chose debit/credit cards as their payment option. The most common reason for failure was a missing 3DSecure support of the credit card. However, in several instances, the reason for failure remained unclear. P26 got stuck on an infinite loading screen; P1 was redirected to a white screen without any content; for several users, credit card payment failed without any explanation. P31 summarizes her experience with, "*This is super complicated! It seems as if they don't even want me to buy Bitcoin!*"

Alternative Payment Options Offer Worse Experience: Alternative payment options, i.e. bank transfer, were used by only few participants and offered a worse experience than credit/debit cards. Users generally selected them only after credit/debit cards did not work. First, users generally expected their cryptocurrency or deposited Euros to be available immediately after the purchase and were often surprised if it was not the case. While deposit times were communicated by wallets, they were not visible enough for users, who just skipped over them. After completing their transaction with SOFORT Überweisung, P8 proclaimed, "*I think I am a proud owner of Bitcoin now... or not.*", only to later realize their mistake. Ambiguous or unclear presentation of the deposited money led to misconceptions of users: with no indication of the deposit, users were anxious it might have failed. With an ambiguous visualization, not emphasizing the *pending* status, users believed it had worked in an instant.

4.3 Cryptocurrency Challenges

Cryptocurrencies remain hard to deal with, even when taking key management out of the equation. We found several issues that participants found consistently challenging.

4.3.1 Dealing With Cryptocurrency Requires Mental Effort. Dealing with cryptocurrencies is hard. We observed several reasons why this is the case.

Users Mentally Convert Cryptocurrency To Fiat. We observed that novice users *think in the currency of their country of residence*: When purchasing or spending Bitcoin, users consistently resorted back to using their home currency. Wallet interfaces acknowledge this behavior to a certain extent. For example, the overall account balance is shown primarily in the fiat currency. Interfaces for sending Bitcoin proved more difficult to handle. Several users did not enter the purchase amount in Bitcoin as requested by the merchant but in Euros. This behavior can be problematic when the entered amount is interpreted as Bitcoin and users fail to notice — sending 15 Bitcoin by accident would be a quite costly mistake.

Different Exchange Rates Confuse Users. Due to the decentralized and volatile nature of cryptocurrencies, wallets and merchants frequently use different exchange rates. This caused over- or underpayments as users entered requested purchase amounts, not in Bitcoin but fiat currency, and used a toggle to convert to Bitcoin. Having calculated with the exchange rate of the wallet, the amount of Bitcoin sent did not match the one requested by the merchant.

Sub-comma Amounts Are Hard To Deal With. Handling small subcomma amounts when sending transactions proved challenging. Our observations indicate that dealing with amounts — e.g. sending *0.0015664788* Bitcoin compared to *15* Euro — increases effort for users. Users avoided manually entering values and instead used Copy&Paste. However, due to different localization of the decimal separator ("." vs ",") the input fields frequently rejected the pasted values. Manual entry required users to switch back and forth between the merchant and wallet interface multiple times: first, to enter the value, then to check it. User interfaces only accepting six decimal places even though Bitcoin extends to 8, lead to further confusion among users.

4.3.2 Fees Are Unexpected, Intransparent And Complicated. Networks fees are an essential part of how cryptocurrencies work as they incentivize miners to validate transactions. Previous work has recognized fees as a source of misconception for users [29]. Our findings add a dimension to it. Not just network fees are complicated to understand, but also platform fees introduced by the wallets. Users need to be aware of five types:

(1) **Deposit Fees** are charged by the wallet when users deposit money.
(2) **Exchange Fees** are charged by the wallet when users exchange currencies.
(3) **Withdrawal Fees** are charged by the wallet when users withdraw money. (not present in our study)
(4) **Merchant Fees** are added by the merchant on top of the purchase price of an item.
(5) **Network Fees** are added to a cryptocurrency transaction to incentive miners.

Users criticized the lack of clear explanations regarding fees. When asked after the study, the majority had little to no understanding of what fees were paid for and to whom they were paid. Consequently, users were surprised by the amount of fees paid during the

study. P8 complained, "*This is exorbitantly overpriced!*". On average, fees amounted to 2.15 EUR, with one participant paying a total of EUR 10.20 in fees during the study. This was caused by automatically calculated network fees amounting to 9.35 EUR, showing the downside of using heuristics for fee calculation [29]. A positive counter-example here was the wallet of TenX, which charged a flat fee of EUR 0.82 per cryptocurrency purchase.

Mental Model: What You See is What You Pay. We observed another aspect concerning Network Fees worth reporting. Users did not expect to pay fees when sending a transaction to the merchant. They expected the price tag of a product to be the final checkout value without any fees added — to buy a product priced 15 Euros, one pays 15 Euros. This hints towards the mental model of users: when buying products, European consumers are used to what-you-see-is-what-you-pay type prices.

4.3.3 Transaction States Are Intransparent. Cryptocurrency transactions undergo several steps before completion. They are published to the network, are validated and added to the blockchain, and finally considered valid only after a certain number of blocks — in the case of Bitcoin 6 — were added subsequently. Generally, novice users lack this technical understanding. Most participants believed that Bitcoin transactions would be in real-time and felt that waiting times were long and not sufficiently communicated. However, user interfaces displayed the status of transactions in ways that presumed this knowledge — i.e. "pending", "1 confirmation", "2 confirmations", ..., "confirmed", leading to confusion among users. Additionally, the states of transactions were displayed differently between the merchant and wallet, causing confusion about whether the transaction had actually succeeded. The merchant displayed transactions the moment they were published, yet not included in a mined block — users assumed the transaction was completed. Contrary, the wallet displayed the transaction as pending and neither was the purchased good, i.e. the voucher, delivered to the user's inbox.

4.3.4 The Payment Process Is Manual And Complicated. Users perceived the payment process as manual and complicated. Most expected that paying with cryptocurrency would be "*as easy as with PayPal*". Instead, they faced a manual process.

Missing Guidance For Novice Users. Upon completion of the checkout process users were presented with the requested purchase amount and a Bitcoin address to which they should send it. The checkout screens missed any further instructions for beginners. Additionally, the used language assumed knowledge of cryptocurrency-specific concepts. However, terms like "wallet" or "address" had ambiguous meanings for novice users. Confirming previous observations [2], several users did not recognize the address. P3 tried to enter the URL of the merchant's website, the Invoice ID, and the email address before considering the actual Bitcoin address. P15 did not think of their cryptocurrency app when reading "wallet", opening Apple's Wallet app on their iPhone instead.

Poor Checkout Process Integration Between Merchants And Wallets. The manual nature of the checkout process manifested in the missing integration between merchants and wallets. While merchants provided a QR Code and an "Open in Wallet" button intended to serve as shortcuts, they did not work. Both encoded a link in a URI-like format — "bitcoin:38Ap73vjNae5SaUBJXVS46muvRKk6Cikgf ?amount=0.020685". In the majority of cases, they failed to work. The link failed for any web-based wallets on desktop devices and only one mobile app responded. However, instead of processing the encoded parameters, it only opened the main screen of the app. Additionally, QR codes were hardly used. Except for one participant, users remained on one device throughout the checkout process. Scanning the QR Code when it is displayed on a desktop device would require an additional device switch users were not willing to make. Scanning the QR Code with the smartphone, it is displayed on is simply not possible.

Manual Payment Process Increases User Workload And Errors. Resulting from the lack of guidance and missing shortcuts, the payment process proved error-prone. Users had to manually switch between apps, locate the right functionalities to send transactions, and copy addresses and amounts between them. This lead to increased workload, frustration, and errors among users. Within the wallet apps, users struggled to locate the functionality to send a transaction. Copying the value from one app to another was perceived as a manual process that also lead to errors. Overall, 9 participants did not send the right amount of Bitcoin to the merchant.

5 DISCUSSION

Our results show that state-of-the-art cryptocurrency applications fail to address the needs of novice users. Many challenges do not arise from the underlying constraints of blockchain technology. Thus, developers may already improve their applications' usability significantly by applying existing guidelines such as Shneiderman's Golden Rules, or Nielsen's Usability Heuristics [34, 44]. Challenges specific to cryptocurrencies may prove more difficult to tackle. In the following, we present design implications for practitioners and highlight open questions for HCI research. Future work may build on these findings to develop guidelines on how to develop cryptocurrency wallets for beginners.

5.1 User Interfaces For Novice Users

Interfaces built for experts increase entry barriers and the likelihood of mistakes for new users. Previous research recommends adapting cryptocurrency tools to the risk perception of users [15], to diverging mental models [29], or to implement different interfaces for experts and novices [2]. We complement these recommendations with concrete suggestions on how to improve interfaces for novice users.

5.1.1 Present Relevant System Status and Interactions. Clearly and unambiguously communicating the status of a system to users is key to helping them bridge the gulf of evaluation; making important interactions easy to find also helps to overcome the gulf of execution [48]. Current wallets fail to adequately do so for new users as they present too much irrelevant information in domain-specific language, inadvertently hiding relevant information. Developers need to focus on making essential features easy to access [2], specifically system states and interactions related to account verification, buying cryptocurrency, and sending transactions.

5.1.2 Support Users' Learning Experience. Cryptocurrencies are a complicated topic to understand. Even established users frequently have incomplete or incorrect mental models [29]. Adaptive user interfaces and carefully crafted onboarding experiences could support users' learning experiences, gradually guiding them towards a more complete and correct understanding. Future research should investigate which information is crucial for users to form a functional mental model [38] of cryptocurrencies and how to translate it into user interfaces. To identify adequate ways, we encourage researchers to explore strategies deployed in the wild and involve users in the design process of new ones.

5.2 A Frictionless Signup Experience

The extended registration process is a major cause for frustration among novice users. Being required by regulation, reducing friction is crucial to avoid users abandoning applications before they unlock their full functionality. From our observations, we present implications for practitioners. The many issues related to the extended signup process indicate that this area could greatly benefit from HCI research. With increasing regulation, digital identity verification will become more prevalent as well. Understanding how to better design these could benefit applications in domains beyond cryptocurrencies, such as finance, micro-mobility, and e-government.

5.2.1 Inform Users First. KYC processes require users to disclose significant personal information. Often users do not know why the information is collected. It is crucial to clearly communicate the purpose behind inquiring about this information before the start of the process. Hyperlinks similar to "Terms and Conditions" notices should be avoided as users commonly ignore them [40]. Instead, explanations should be placed prominently, in such a way that users notice and read them. For compliance reasons the original legal texts may still be required to be linked, but the initial explanation should be written in a friendly manner and avoid technical or legal jargon when informing the user.

5.2.2 Eat the Biggest Frog First. Giving users access to the main interface before the extended verification process was completed resulted in an increased mental workload of users. Instead of clear guidance, now they had to find a way to start the verification process amidst the many features they could see, yet not use. Mark Twain is quoted to have said "*If it's your job to eat a frog, it's best to do it first thing in the morning. And if it's your job to eat two frogs, it's best to eat the biggest one first*". Given the unwanted friction and legal "must-have" quality of the extended signup process, it is fair to label it as a "frog", a big one in fact. Apps should guide the user through this process first, keep them informed about their progress, and only then present the full interface.

5.2.3 Provide An Integrated KYC Experience. Identity verification is commonly provided by third-party providers. "Lazy" integration of their frameworks breaks the user experience, causes confusion, and may lead to the cancellation of the process. Developers should aim for full control of the user experience during the verification process, including design language, the internal status of the verification process, and information — i.e. in the form of notifications — directed towards the user. Well-designed KYC processes should give users the feeling that they never leave the original application.

5.2.4 Expect Interruptions and Device Switches. Verification processes are likely to be canceled by users because they do not have the right documents ready, have connection issues, or face other technical difficulties on their device. Developers should account for this behavior and anticipate interruptions and device switches by the user. Each step of the process should, therefore, be stored and synchronized across devices, so users can seamlessly continue after interruptions.

5.3 Transparent Fees

While previous work addressed users' understanding of network fees [29], we find that the fees charged by custodial cryptocurrency platforms are equally difficult to understand. From this, we derive two implications.

5.3.1 Comprehensible Platform Fees. Platform fees should be communicated to users with utmost clarity. HCI can help design interfaces to this end, but there is a limit to how well complicated fee schemes can be explained. Wallets should aim to implement simple and consistent fee schemes, reducing the types of different fees. Easily comprehensible fees will avoid surprises, reduce frustration, and increase the long-term experience for users. We understand that such decisions are integral to the business models of companies developing wallets. High fees and a poor user experience will, however, only open the door for competition in the long term. Looking beyond cryptocurrencies, emerging brokerage startups have managed to simplify the traditionally complicated fee structure while staying profitable — e.g. digital brokerage platform TradeRepublic[11] offers a flat 1-Euro-Per-Trade fee. There is no reason why centralized cryptocurrency exchanges should not be able to do so as well.

5.3.2 Efficient Network Fee Visualization. Network fees are essential to how cryptocurrencies function, yet hard to understand for novice users. Mai et al. suggest heuristically pre-computed network fees labeled with easy-to-understand terms — i.e. "slow", "default", or "fast" [29]. We suggest additional features. In line with Nielsen's Help and Documentation heuristic [34], interfaces should explain the purpose of network fees in proximity to where they are shown. Explanations should avoid technical jargon, instead of focusing on users' tasks and how fees will influence the outcome — i.e. how fast the transactions will be completed. Presenting information aligned with users' mental models is key to making it easily interpretable: How many minutes does a "slow" transaction take? When will the transaction be completed? The same applies to communicating the cost of a transaction — presenting it in fiat currency or as a percentage of the overall transaction value might increase comprehension: distinguishing between 0.5 EUR and 5.0 EUR, or 1% and 10% requires little effort, compared to spotting the difference between 0.00004779 BTC and 0.0004779 BTC. As these small sub-comma values are prone to errors, interfaces for transactions should provide smart warning mechanisms [2] — e.g. based on fees typical of a specific cryptocurrency or the ratio between the fee and the transaction value. Smart warning mechanisms would further provide protection against both accidental user errors, so-called "Fat Finger Transactions", and errors in the heuristic fee calculation.

[11] https://traderepublic.com/

5.4 A Seamless Checkout Process

For establishing cryptocurrencies as a viable tool for online payment, much work remains to be done. Previous research recognizes the availability of merchants accepting cryptocurrencies [15], slow transaction times [2] and trust issues [41, 42] as open challenges. Our findings suggest that the manual payment process is another major challenge. Users expect a checkout process "*as easy as PayPal*" — current solutions however are manual, demand high interaction cost from users, and are prone to error.

5.4.1 Provide Adequate Guidance and Shortcuts. Merchant interfaces lacked guidance along the checkout process and used language that was easily misinterpreted ("wallet", "address") by novice users. Merchants should provide guiding explanations in plain language in the context of the checkout process to support users to correct misconceptions. While shortcuts (QR Codes, hyperlinks) between merchants and wallets promise to remove much friction from the process, adoption and interoperability lack behind. Wallets and merchants should work on establishing standards to transfer the wallet address and the transaction value automatically, reducing both interaction costs and the risk of "fat finger" mistakes. There remain several open questions to be addressed by HCI research. While shortcuts reduce manual work, they are also susceptible to attacks [26]. We encourage researchers to explore how methods to compare transaction data – e.g. [46] – can be implemented in the context of cryptocurrencies. Furthermore, it is unclear how transaction states should be presented. Current cryptocurrency systems have not yet developed a common understanding, resulting in ambiguous, confusing approaches. HCI research should explore how transaction states can best be displayed; how to communicate the necessary information, without presuming knowledge of the underlying technology.

5.4.2 As Easy As PayPal. While the recommendations above allow for an iterative improvement of the current checkout process, future research should explore how cryptocurrency payments can become truly frictionless. Many properties of Bitcoin — long alphanumerical addresses, high valuations, and high volatility, slow transactions — are difficult to handle and are not well suited for real-time purchases. Practitioners have noticed and addressed these issues through new solutions: the Ethereum Name System provides a DNS-like abstraction layer for cryptocurrency addresses; so-called Stable Coins aim to reduce volatility; and the Bitcoin Lightning Network enables real-time point-of-sale transactions. These and other technical improvements each solve important issues on their own. Most HCI research on cryptocurrencies today evolves around Bitcoin. Future research should explore how these new technologies can be integrated to enable truly seamless payments with cryptocurrencies.

6 CONCLUSION

This paper explores the interaction of first-time cryptocurrency users with custodial wallets. Our analysis reveals numerous challenges novice users need to overcome to engage with the technology, most prominently user interfaces designed for experts, a painstaking registration experience, and a manual and error-prone checkout process for paying with cryptocurrencies. Presenting the first investigation into custodial wallets, we reason that some of the identified challenges might be relevant in the larger context of finance apps. Rooted in these findings, we present design implications for practitioners and discuss how these challenges can be addressed by HCI researchers and practitioners. We think, moving towards usable cryptocurrency applications is an attainable goal and hope our work provides a valuable resource to direct future research on how cryptocurrencies can be made accessible to a broader range of people.

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