Mobile Phones as Amplifiers of Social Inequality among Rural Kenyan Women

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This article provides a detailed analysis of rural Kenyan women and their interactions with the products and services of Safaricom Ltd., Kenya's dominant mobile network provider. The amplification theory of technology offers a framework for analyzing our data, and we find that differential motivation and capacity are mechanisms that appear to benefit the network provider, while disadvantaging rural mobile phone owners. In particular, the design of Safaricom's airtime scratch cards and mobile services does not support rural users' capabilities. Our analysis suggests that technologists consider their ongoing responsibilities for technologies they built yesterday—that is, they should address problems inherent in the current design of mobile-phone interfaces. We offer practical recommendations on how to do this, and ask HCI/ICTD researchers and practitioners to more carefully consider how overlooking corporate power structures and their impact on mobile phone use amplifies social inequality.

Categories and Subject Descriptors: H.5.2 [**Information Interfaces and Presentation**]: User Interfaces—*Evaluation / methodology*

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1. INTRODUCTION

The role of information and communication technologies (ICTs) in international development is disputed: some believe that greater access to ICTs—in particular, the mobile phone—can enable socioeconomic growth in developing countries [Brewer et al. 2005], and some question this [Toyama 2011, 2015]. In this article, we offer another perspective, arguing that although ICTs benefit entities in developing countries, those entities are not necessarily the marginalized populations that technologists in HCI and ICTD target. Instead, widespread mobile phone ownership in Kenya benefits Safaricom Ltd. (the country's dominant mobile network provider), thereby amplifying the

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existing institutional forces that benefit for-profit companies, at the expense of rural phone owners.

In this article, we present findings from two field research trips to rural Kenya, where we visited nine sites and interviewed 68 mobile phone users, twice each. Our data analysis was framed by the amplification theory of ICTD, and our findings support Toyama's conclusion that technology "tends to amplify existing social inequalities" [Toyama 2011, 2015]. Findings from group interviews and observations of rural women's interactions with Safaricom's products and mobile services suggest that, by not accounting for rural-vs-urban differentials in motivation and capacity, the disadvantaged become more disadvantaged, while Safaricom continues to profit. These findings demonstrate why technologists in HCI and ICTD must account for critical differences between rural low-income populations and the private sector, and draw attention to flaws inherent in the design of mobile phones—in particular, their interfaces.

The rest of our article is structured as follows. We describe Safaricom Ltd., introduce amplification theory of ICTD, and then, review related research including prior studies of Safaricom's mobile services (in particular M-Pesa) and HCI/ICTD intervention projects. We then present our findings, which are organized around these mechanisms of amplification: "differential motivation" (i.e., people want to do different things with technology) and "differential capabilities" (i.e., those with more education and social connections will benefit more from ICT access than those with less) [Toyama 2011]. Our analysis suggests that technologists consider their ongoing responsibilities for technologies they built yesterday [Dourish and Mainwaring 2012]—that is, they should address problems inherent in the current design of mobile-phone interfaces so that they are better aligned with rural user' capabilities and usage practices. Finally, our findings are in accordance with other researchers' calls to devote more attention to understanding how corporate power structures affect mobile phone use [Irani et al. 2010], because a lack of understanding may amplify existing forces—specifically, the further marginalization of rural populations in Kenya.

Contributions of this research include detailed accounts of rural Kenyan women's experiences with their mobile phones, which demonstrate a mismatch between their capabilities and the design of Safaricom's products and mobile services. We also offer empirical support for amplification theory, as applied to exacerbating economic differences between a for-profit company and rural mobile phone owners in Kenya; this ultimately offers new design and research directions for HCI researchers and practitioners.

2. BACKGROUND AND RELATED WORK

2.1. Safaricom Ltd.

Soon after the introduction of mobile telephony into Kenya in 1997, Safaricom Ltd. captured the highest market share in the country and has maintained that leadership ever since. As a result of inefficiencies in the Kenyan economy, Safaricom has also added to its core business by introducing various supporting services. Its most publicized achievement has been M-Pesa (introduced in 2007), a mobile phone-based money-transfer system; it has also introduced other services, including "Skiza Tunes (a music download feature) and "Please call me" messages [Mudavadi and Weber 2013]. The company has a strong brand presence: structures painted "Safaricom Green," which prominently feature the company's logo and advertise M-Pesa, are a ubiquitous feature of the Kenyan landscape. The company is also associated with people's concept of a modern Kenya, and it has made efforts to negatively portray nepotism, inefficiency, and corruption [Mas and Morawczynski 2009].

Safaricom is Kenya's dominant network provider, with an estimated 68% of the total market share of the country's estimated 32.8 million mobile subscribers. It is also the most profitable company in East Africa; in March 2015, the company reported yet another highly profitable year, posting KES 31.9 billion (USD 336 million), 38% more than the previous year [Ombok and Wachira 2015]. Prior research suggests that the company's services are largely marketed to well-off urban dwellers in Nairobi [Kuriyan et al. 2012; Mudavadi and Weber 2013]; who are more likely to speak English, to have more disposable income, and to be more knowledgeable about how to use ICTs, than the country's low-income rural residents who make-up nearly 80% of the Kenyan population [The World Bank 2014; Crandall et al. 2012]. Our research focuses on this segment of the population who also make up a significant percentage of percent Safaricom's customer base.

2.2. Amplification Theory for ICTD

Toyama writes that "It would be nice if technology did more for the poor, uneducated, and powerless"—or populations like the rural women we studied—"than it did for the rich" [Toyama 2011]. He argues that ICTs—either alone, or in conjunction with the for-profit companies developing technologies—cannot alter such inequalities because of the "law of amplification," which states that technology's primary effect on society is to amplify existing forces [Toyama 2015]. According to the amplification theory for ICTD, technology itself cannot increase a person's innate capacities, but *can* multiply the existing human capacity and intent.

In *Geek Heresy*, Toyama [2015] tells readers that this "idea is so simple and widely applicable;" he uses the amplification theory to critique well-intentioned efforts to improve education in developing countries by providing children with technology (e.g., "One Laptop Per Child"), and for-profit companies' schemes to solve poverty (e.g., the Toms Shoes' marketing campaign that promises when a pair of shoes are sold, a pair will be donated to a "person in need"). Rather than improving marginalized populations' well-being and livelihoods, such "clever gadgets" cannot make up for the "lack of good teachers or good principals"—problems that hinder education in many developing countries. Furthermore, social entrepreneurial efforts to alleviate poverty by encouraging people to buy more are fashionable, but more often than not (as in the case of Toms Shoes) result in multimillion dollar profits for a company while "stunt(ing) local economies and perpetuating(ing) a culture of dependence" [Toyama 2015].

We extend the geographic and comparative ranges of Toyama's work by applying "mechanisms of amplification"—specifically differential motivation and differential capabilities—to analyze the design of Safaricom's products and services. Our analysis suggests that their design at the very least contributes to confusing and complicating our rural Kenyan respondents' abilities to use their handsets, and at worst, results in them losing money to the country's for-profit network provider.

2.3. M-Pesa Research

Our study also builds upon previous research examining Safaricom. Until now, the majority of this research has focused on the impacts of M-Pesa. Here, we investigate the rural realities underlying the use of this, and of other, less-studied services (i.e., airtime scratch cards, "Please call me" messages, "Premium Rate" services, and Skiza Tunes). M-Pesa is a for-profit mobile money-transfer application that facilitates the direct transfer of Kenyan Shillings (KES) (in electronic form) between mobile phones; it is the company's most successful service. This innovation is lauded as an ICTD success story, because of its widespread adoption and use: since its introduction in 2007, nearly two thirds of Kenya's adult population use the service to transfer millions of shillings every month [Hughes and Lonie 2007; Jack and Suri 2011; Mas and Morawczynski

2009]. Within the HCI community, M-Pesa is praised as an innovative way to send money [Kaye et al. 2014], while others support its potential to improve economic and human development [Aker and Mbiti 2010]. However, M-Pesa's success could also be viewed as yet another example of technology amplifying existing intent, specifically a company's desire to turn a profit.

Safaricom Ltd. has made significant profits from extensive use of M-Pesa, which now contributes to 20% of the company's total revenue—earnings that largely come from transaction fees [Mas and Ng'weno 2010]. The company's customers have also benefited, but more modestly; questions remain about the impact such services have on the livelihoods of low-income peoples [Donner 2008; Donovan 2015; Morawczynski 2009]. Findings from prior research do suggest that M-Pesa has provided Kenyan women with a safe place to store their money [Morawczynski 2009], has made it easier for service users to recover from financial shocks (e.g., job loss or failed harvest) [Jack and Suri 2014], and facilitated the transmission of remittances from urban residents to their rural friends and relatives [Mas and Ng'weno 2010]. In addition to enhancing existing remittance behaviors, other factors have contributed to mobile money's unique success in Kenya; these include Safaricom's strong marketing/branding efforts [Kuriyan et al. 2012; Mudavadi and Weber 2013], a familiar and intuitive interface design [Mas and Ng'weno 2010], and an expansive network of agents, which make withdrawing and depositing cash possible from nearly anywhere in the country [Morawczynski 2009]. Yet, it is Safaricom's dominance as Kenya's mobile phone network provider—one of the world's least competitive telecommunication markets—which researchers view as the primary factor contributing to the service's remarkable performance [Donovan 2015; Mas and Morawczynski 2009; Mas and Ng'weno 2010]. This market dominance concerns some scholars and consumer advocates.

Donovan reviews the consequences of the "network effect"—the fact that much of M-Pesa's utility comes from its near-monopoly (>95%) on Kenya's mobile money market, writing "this can lock in customers more tightly to an operator that reaps considerable profit from the service" [Donovan 2015]. He describes mechanisms Safaricom uses to make M-Pesa the country's "standard" way to transfer money, such as imposing higher transactions fees on users wanting to send money to non-Safaricom subscribers, thus incentivizing them to save money by ensuring that all the members of their networks use Safaricom [Donovan 2012].

2.4. HCI/ICTD Invention and Intervention Projects in Kenya

By exploring Kenyan's interactions with mobile services that are used by millions and already operating at scale, we draw lessons for technologists in HCI and ICTD, who are developing mobile phone applications, which aim to lessen inequalities by providing marginalized populations with pertinent information (i.e., health, job opportunities, etc.). Within the CHI research literature, much of this research has taken place in India (e.g., Gupta et al. [2012], Parikh et al. [2006], and Patel et al. [2010]); for the purposes (and scope) of this article, we review studies that happened in Kenya.

Motivated by high unemployment in Kenya and the perceived income-generating possibilities that come from widespread mobile phone ownership there, Eagle created "txteagle," a mobile crowdsourcing platform "that enables people to earn small amounts of money by completing simple tasks" [Eagle 2009]. "Safe Mathare" is another prototype application developed for Kenyans, with the specific purpose of helping protect female Nairobi slum-dwellers from crime at night by "find(ing) trusted others to accompany them as they walk around the slum" [Hagan et al. 2012]. More recent HCI interventions include Perrier et al.'s development of a novel "hybrid computer–human SMS system"

that provides pregnant women in urban Kenya with health information [Perrier et al. 2015].

Each of these studies represents a useful technological advance that may provide some benefits to communities in Kenya. In most cases, their developers recognize that, for these projects to have their intended impact, they must scale to reach populations beyond the small numbers of research participants on which these studies are based (see Perrier et al. [2015]). However, as Zuckerman observes [Zuckerman 2010], "Truly revolutionary applications (. . .) have generally been deployed in tight collaboration with network operators;" thus, for the aforementioned projects to achieve this scale, their developers will likely have to partner with a network provider, such as Safaricom. Our findings reveal how such partnerships may amplify some of the socioeconomic problems these interventions seek to solve. Finally, these findings also build upon prior studies of women's mobile usage practices in rural Kenya [Murphy and Priebe 2011; Oduor et al. 2014]; and in India [Kumar and Anderson 2015], unlike these studies, our focus is on women's interactions with their mobile network provider's services.

3. OUR STUDY

3.1. Site Selection: Kenya

Kenya's mobile phone ownership rate is 75%, a figure significantly higher than the African average of 65% [Crandall et al. 2012]. This greater penetration is attributed to advancements in technical infrastructures, favorable government policies, and an active private sector. Mobile phone prices have also dropped, making them more affordable to the country's low-income and rural residents. We interviewed and observed residents living in poor underdeveloped communities, who are fairly representative of the low-income mobile phone owners living in rural Kenya. Our field sites were in Bungoma and Homa Bay counties, both of which are in Western Kenya near Lake Victoria, 6–8 hours by bus from Nairobi. These are agrarian areas, where limited employment opportunities mean incomes are typically low; however, as is the case throughout much of Kenya, mobile phone ownership is high [Wesolowski et al. 2012]. Low-skilled workers in the region typically earn a wage of about KES 150–200/day (USD 1.45–2.00/day) [Murphy 2008].

The second and third authors are from, and currently live in, these counties. Both are known within them, and relied on contacts made through their personal and/or professional pursuits to recruit study participants, and to organize sessions. They moderated interviews, first explaining the purpose of the sessions, and then, asking respondents for informed consent; by and large, individuals were happy to take part. Respondents were encouraged to speak in the languages they were most comfortable with, although codeswitching also occurred (i.e., in Bungoma county, typically Swahili and Bukusi; in Homa Bay, typically Luo). Participants used English terms, in particular when referencing mobile phone features and functions. The first author—who primarily speaks English—did not moderate sessions, and took fieldnotes during them.

3.2. Methods and Study Participants

We conducted observations and group interviews to understand rural women's interactions with their mobile phones and Safaricom's services. These data were collected as a part of a long-term project that examines the use of video clips to improve rural residents' "device literacy" [Wyche et al. 2016], that is, their ability to use all the tools and functions embedded in their mobile phones [Velghe 2014]. To date, this project has involved the primary author—a U.S.-based, HCI researcher with significant research experience in sub-Saharan Africa—travelling to sites in rural, western Kenya, three times (May 2013, September 2014, and June 2015) to collect data with the assistance

of the second and third authors. Findings presented in this article primarily draw from the second and third field research trips. Our analysis was also informed by the authors' experiences as Safaricom customers, by informal conversations with Safaricom employees working at their shops in Nairobi, Kisumu, and Bungoma, by articles from Kenya's major newspaper the *Daily Nation*, and by examination of Safaricom artifacts (i.e., scratch cards, promotional materials, the company's website,[1] and Facebook page[2]). As a result of collecting data from multiple sources, our understanding of Safaricom's services was more comprehensive than would have been possible with only interviews and observations.

The first round of data collection occurred in May 2013, where we learned about the challenges rural residents—particularly women—encounter when using their mobile phones [Wyche and Steinfield 2015]. We decided to focus our research efforts on women, because they tended to be less capable of using their phones (compared to men) and returned to our sites in September 2014 and conducted nine women-only group interviews (total: 68 participants). The criteria for being part of the sample population for each study were that one had to be a woman and own a mobile phone. During these sessions, we collected some demographic data, including women's ages and years of schooling. We also documented the type of mobile phone each woman owned, noting its brand, model number, condition, and available airtime, and reading some of the text messages in their handsets' inboxes.

We developed and used an interview protocol so that all sessions covered the same topics, but kept the sessions open-ended and conversational, to allow for the discovery of unexpected themes. These topics were formulated broadly and included questions about what women did—and did not use their phones for—and how they learned to perform mobile phone tasks (e.g., composing, sending, and deleting text messages, adding new names to their contact lists). The questions were accompanied by having the women perform—or attempt to perform—the relevant activities. We photographed and digitally recorded each session, which lasted 2–3 hours.

These meetings were useful forums for participants to openly discuss the benefits of phone ownership and to express their frustrations with both the devices and their network provider. Findings from these group interviews also guided the development of five, 2–5 minute video clips that offered instruction on how to write and send a text message, delete text messages, and manage Safaricom services.

In June 2015, we returned to the sites to update the women on the project's status, to give them copies of the photographs taken of them, and to show them the videos. We also distributed 100 KES (about USD 1) Safaricom scratch cards to women in our sessions. These were compensation for participants, and were also to be used when trying out the activities in the videos (i.e., sending an SMS). Discussing the effectiveness of using video clips to improve rural women's device literacy is not central to this article; however, the videos proved useful for eliciting comments from respondents about their mobile phones. These comments, along with those from the preceding research trip, were included in our analysis.

3.3. Analysis

Similar approaches guided the analysis of data collected from both field research trips. Analysis began in Kenya, and included writing fieldnotes and discussions among authors about similarities and distinctions pertaining to phone use that emerged during each session. The second author then translated and transcribed recordings from the sessions. Upon returning to U.S., the first author adopted an iterative, inductive

[1]Safaricom: http://www.safaricom.co.ke/.
[2]Safaricom Kenya Official Page: https://www.facebook.com/SafaricomLtd?fref = nf.

approach typical in anthropology, thereby pairing an understanding of participants' worldviews with prior research in HCI [Medhi et al. 2011; Perrier et al. 2015] and critical perspectives drawn from ideas from the amplification theory [Toyama 2011, 2015], and postcolonial computing [Dourish and Mainwaring 2012; Irani et al. 2010] when analyzing transcripts; specifically, she looked for frequent and consistent instances in the data that revealed a mismatch between our respondents' capabilities and Safaricom's products and services. This analysis involved reading transcripts four times, and coding them to identify similarities among participants and their mobile phone use experiences [Strauss and Corbin 1998]. Data triangulation occurred across data (i.e., fieldnotes, transcripts, photographs, online media, and collected artifacts). Throughout this process, the authors engaged in regular phone and email discussions to clarify and confirm our findings. To improve the accuracy of these findings, the second and third authors called individuals from each group to confirm particular aspects of the data, that is, they engaged in "member checking" with some respondents [Krefting 1991].

4. FINDINGS

Before we discuss the findings in regards to technology amplification, we describe our respondents and the mobile phones they owned. Then, we tell how they most frequently use their phones: receiving voice calls and sending "Please call me" messages (henceforth, PCM). These findings reveal how the "differential motivations"—between what Safaricom wants to do with technology, and what our rural respondents want to do with it—affect the design of the company's products and services. Next, we describe "differential capacity," expanding on this concept by suggesting that inequalities are amplified by disparities in rural residents' visual capabilities (and by Safaricom's nonoptimal interface design, which makes unsubscribing from pay services difficult), to the extent that mobile phone ownership was a net loss for some of our respondents.

4.1. Overview of Women, Their Handsets and Usage Practices

Data presented here comes from 68 women who participated in the study; roughly all who attended the first sessions were also at the second session where the video clips were presented. Fifteen of these women were in their 20s, 21 were in their 30s, 19 were in their 40s, 12 were in their 50s and 60s, and one was 70. Nearly all reported their primary residence as being in a rural area and identified as smallholder farmers, holding one to five acres of land. Although, as is common, many also engaged in other income-generating activities, including selling charcoal or produce at local markets. Slightly more than half of women had relatives working in Nairobi or nearby Kisumu. All participants, like most rural women—especially, those who are married—had time-consuming marital responsibilities, including child-rearing, working in their "shamba" (Swahili for garden or field) [Ngimwa et al. 1997]. Most women under the age of 40 had primary school education, a few had attended secondary school; four were college educated professionals. All of these women spoke Kiswahili and some English, while those who were older than 40 generally had lower education levels and were less fluent in these languages and most comfortable speaking the local dialects (primarily Bukusu or Luo).

Feature phones called "kaduda" were the most common handsets owned, three-quarters of which were substandard "China-makes" with Bird, Itel, G-Tide, and Tecno brands. These phones are affordable and popular because unlike basic original handsets they tend to have color screens and dual SIM card slots. We did encounter some original Nokia and Samsung handsets; however, more common were the low-quality counterfeit Nokia 1100 models, which have become increasingly common in rural parts of Kenya [Wyche et al. 2015; Wyche and Murphy 2012]. Six women used their handsets

to occasionally access the mobile Internet, but most did not because they lacked an appropriate handset model.

Having a phone was synonymous with being a Safaricom subscriber, and all but three women had a SIM card from that company. Roughly a quarter of the women, in particular those with dual SIM phone models, also had an Airtel (Kenya's second most popular mobile network provider) SIM card. As is common in Kenya and elsewhere in Africa, knowledgeable consumers buy "lines" from more than one provider so as to maximize the benefits [Chepken et al. 2013]. The majority of women told us they had small amounts of airtime available on their phones (e.g., 2–6 KES) at the time of our session: "zero zero" was a typical response to our question about the amount of credit, and we encountered women with negative airtime balances.

4.2. Differential Motivation: Voice Calls and Please Call Me Texts (PCM)

"Communication"—specifically receiving voice calls—was the most frequent answer to our question about what the device was used for. Toyama writes, "A mobile phone allows people to perform desired tasks across greater distances, with more people at a greater frequency than would be possible without one" and—as has been observed elsewhere [Molony 2008; Murphy and Priebe 2011]—this is how our participants used their phones. Women mostly received calls from friends and relatives living far from them, to send "greetings" and to share family updates, such as a birth or death. Furthermore, receiving a call was an operation all participants were capable of performing, and (as respondents told us) required pressing only the "red and green buttons" on their handsets.

As was the case in Crandall's study of rural Kenyans, we found that our respondents rarely sent text messages [Crandall 2012]. However, all used the PCM service ("Tafadhali nipigie simu" in Swahili) which Safaricom provides its subscribers. Sending one of these prepared messages appears to have replaced "beeping," also known as "flashing"—the widespread phenomenon of dialing a phone number and hanging up before the mobile's owner can answer the call [Donner 2007]. Sending a PCM requires entering a short code (*130*) followed by a recipient's number. Safaricom markets PCM as "Flashback 130;" it was developed in response to the company's former CEO's concerns about beeping—a practice, he described as "frustrating" and a "bother" because it "congest(ed) networks" (and because the company was unable to earn revenue from it) [Jopson 2007]. As with flashing, the service is free; unlike with flashing, users can only do it five times per day, and can only do it with other Safaricom subscribers. Along with the text asking, the recipient to call the sender, Flashback 130 messages also include an advertisement for the Safaricom's "premium rate services" (see Figure 1, left). All participants regularly used their allotted five daily messages—not necessarily because they wanted to receive a phone call, as sending a message was less practical and more symbolic. Instead, as Donner observed [Donner 2007], the text messages were sent in order to maintain and reinforce relationships.

Toyama describes differential motivation as a mechanism that amplifies the gap between the rich and poor, observing that people want to do different things with the technology they can access [Toyama 2011]. Here we see that Safaricom—like most technology producers—is motivated by turning a profit, which means they must financially benefit from people using their mobile network. In contrast, our respondents mostly wanted to use the company's network to communicate with friends and family, by taking advantage of the nonrevenue-generating services the company offers (i.e., receiving calls and sending PCM messages). Their use of these services results in little monetary gain for Safaricom, but we see design decisions that ensure that the company does benefit from these uses. For example, by not allowing rural users to send free PCM to non-Safaricom subscribers, the company demonstrates the "lock-in" strategy, whereby

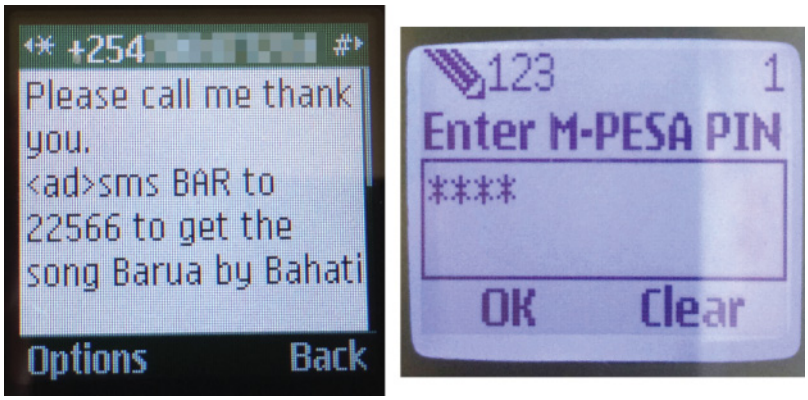

Fig. 1. Mobile Phone Screenshots: (left) "Please Call Me" message with advertisement and (right) M-Pesa PIN Authentication.

subscribers must pay to interact with nonsubscribers; lock-in has also contributed to M-Pesa's success in the country [Donovan 2012]. Furthermore, as we discuss later, the presence of Safaricom's internal advertisements in PCM texts financially benefits the network provider while disadvantaging rural users.

4.3. Differential Capacity and Safaricom Products and Services

Toyama offers differential capacity as another mechanism, which amplifies underlying human and institutional intent. He argues that disparities such as access to "better education, refined social skills, and influential connections all translate to a greater ability for the better to use technology for their own purposes" [Toyama 2011]. In our research, we see how these factors contribute to the disparities in who benefits from ICT, and our findings reveal other ways differential capacity disadvantage rural users, including differentials in visual capabilities and access to information.

4.4. M-Pesa and PIN-Based Authentication

All of the women were familiar with, and had used, M-Pesa, and were pleased to tell us of their delight when their phones beeped or buzzed to indicate that they had received cash, typically from relatives in Nairobi or Kisumu. Most participants rarely sent money using M-Pesa, and they received money infrequently, and—as has been observed in prior studies—often tied to certain times of the year such as in January (when children's school fees are due), or during the "hunger season" (the time between March and June, when foodstocks from the previous farming cycles are depleted and some women needed additional money for food) [Morawczynski 2009]. However, a significant finding missing from this research is the consequences of this sporadic use and how it reveals a mismatch between the design of the M-Pesa and our respondents' capabilities.

Women told us they sometimes forgot the steps necessary to withdraw money on their handsets; the mobile phones models we observed all had different interfaces, none of which were intuitive. On some models M-Pesa is located behind a puzzle icon, on others behind a toolbox icon, and on still others behind a folder icon—and in all cases, users must then navigate hierarchical menus and then scroll to the bottom of a list of rarely-used applications (i.e., Memo, Converter, and Stopwatch) to find the Safaricom selection, and then, M-Pesa (a search and navigation process that is difficult for novice phone users [Medhi et al. 2011]).

The M-Pesa service uses a PIN-based authentication method that requires users to input four-digit codes to retrieve their money (Figure 1, right). A few women described

entering the code as "confusing," and asked why the numbers "changed to stars" upon input. We explained that the goal of substituting asterisks for PIN characters is to prevent other people from watching over a user's shoulder as they enter the PIN, and thereby, stealing it (a phenomenon described as "shoulder surfing") [Wiedenbeck et al. 2006]. More common were instances of respondents telling us that they could not remember their PIN, when visiting an M-Pesa kiosk to get cash. Our conversations with Safaricom employees confirmed this, telling us that rural users' "poor memory" resulted in "lost PINs"—the most common reason people came to their stores looking for help.

Psychological theories tell us that infrequent use of memorized actions results in erosion of one's abilities to perform those actions, and that users are likely to forget passwords/PINS not used regularly, because the memory is not "refreshed" or "activated" sufficiently often [Wixted 2004]. For the rural women we interviewed, forgetting their PIN was time-consuming, because it often required a 1–2-hour walk (or expensive bus ride) to a Safaricom store in a nearby town where they could obtain a new PIN—a service for which the company charged KES 20 in 2011 and KES 22 in 2015.[3] However, the expense was often worth paying if it meant the user regained access to money that had been sent.

Prior research suggests that urban residents are largely responsible for using M-Pesa—sending remittances to their rural friends and relatives [Jack and Suri 2014; Morawczynski 2008]. They are better off, have more money to transfer, and consequently, use M-Pesa more frequently than our respondents—which means they are more likely to remember how to use the services, as well as their PIN codes. Here, we see how design decisions—in particular, PIN-based authentication methods—complicated our respondents' abilities to use M-Pesa.

4.5. Poor Vision, Airtime Scratchcards, and Problems with "Topping Up"

Safaricom's introduction of low-denomination (as low as KES 5–20), prepaid airtime or "scratchcards" in 2008 contributed to the growth in mobile phone ownership among the country's rural residents [Chepken et al. 2013]. Safaricom enlists local entrepreneurs to sell "bamba" (a slang term for sheets, as seen in Figure 2), for a certain amount of money; these enable users to initiate voice calls and talk, and/or to send text messages. Women purchased the cards when they wanted to make a voice call, frequency varied with roughly half of the respondents telling us they purchased a KES 5–10 scratch card weekly, while the rest told us they bought them less frequently. Over the course of our research, and during our group interviews, we saw that—for some women—"topping up" or adding airtime to a handset was overly complicated; others described buying the cards, but not being able to use the airtime.

During all group interviews, the authors distributed individual KES 100 cards to women, so we had numerous occasions to watch them input the numbers into their handsets. In every session, we encountered at least two women who struggled to perform this task that was a necessary step in using their mobile phone. This, and similar comments were regularly heard:

> With me I know how to load the numbers from the card but I have a problem with the eyes, so it takes time.

Indeed, reading the serial numbers printed eight point sans-serif font on the cards was challenging, especially for the middle-aged and older women in the groups. "Mamas" would tell us that they needed eyeglasses. Eyeglasses are not common in

[3]As of January 2016, Safaricom Ltd. no longer charges customers to change their PIN.

Fig. 2. KES 100 Airtime Scratchcard (front and back).

this population; this is likely due to the society's limited ability to deliver appropriate eye care, combined with the difficulty of establishing a sustainable, affordable lens delivery system in Kenya's rural areas [Potter 1998].

Other respondents said that they saw double, or that it was hard to distinguish between similarly shaped numerals (e.g., 3, 6, and 8). In the words of two women:

> I can put, but sometimes I confuse numbers, I have been having the problem with the eyes, I confuse letters I found myself pressing a different letter.

and

> I can see the numbers but I see it two times, when its one, I see it as eleven, when it is one.

Inputting the wrong string of numbers resulted in receiving an automated text message from Safaricom that read, "Voucher number you entered is not correct," one of the many English-language error messages the company sends to subscribers to indicate that a desired operation has failed. Topping up was further complicated by screen parallax, poorly backlit screens, and old handsets with numbers worn off keypads.

Our observations corroborated what we had heard. Some women handed the scratch cards and their handsets to someone else in the group—a process some would be reluctant to do in situations where if they did not know if they could trust the

person, and risk them stealing the number and airtime. Other information on cards was presented in two-and-four point font sizes, including Safaricom's "Terms and Conditions," the company's website address, instructions on how to input the serial number, and the number of days the airtime is valid, were indecipherable for our younger participants.

Many rural households in developing countries, including those where our interviews occurred, still rely on kerosene lamps and candles for lighting and it is believed that the smoke from these sources contributes to vision problems. This prior research also suggests a "very high prevalence of functional presbyopia" afflicts half of rural Kenyan women—a finding reflected in our sample [Sherwin et al. 2008]. Ophthalmology researchers add that this condition complicates farmers' abilities to perform everyday "near vision activities" such as sewing, weeding, or sorting seeds—and, as we learned, adding airtime to their mobile phones. Women also complained about scratching cards and not receiving airtime; in the words of one participant, "The problem is I put money but when I speak the money is not there." We speculated that for some, this may be a consequence of unsuccessfully inputting difficult-to-see serial numbers.

Differential capacity is typically framed in terms of low literacy and unfamiliarity with the devices are reasons given for to rural peoples' problems using the phones [Medhi et al. 2011; Toyama 2015]. For the most part, it was not illiteracy per se that hampered women's abilities to use their handsets; rather, it was their eyesight—a physical factor that also contributes to amplification by making it difficult for our participants use their phones and/or their purchased airtime.

Subscription-Based Mobile Services and Lost Airtime

Another common complaint among respondents was that they often lost money to Safaricom's subscription-based mobile services (e.g., Premium Rate Services and Skiza Tunes), which depleted their airtime and had abstruse instructions for unsubscribing. These findings regarding our respondents' inabilities to unsubscribe from these services best demonstrate how differential capacity amplifies the gap between those who benefit from widespread mobile phone access in Kenya and those who do not.

Although Safaricom described their premium SMS services (also known as GetIT411) in terms of the content they delivered (e.g., Bible quotes, breaking news, and job posts), our participants described them in terms of their cost—"services that deduct your credit." Women reported being spammed with advertisements for these services; the advertisements included the short codes one enters to subscribe. Many—but not all—had learned to ignore these texts, and deleted them immediately. Others described being subscribed to the premium services accidentally, as a result of, e.g., lending their handset to a friend or relative.

"Skiza Tunes" was another commonly mentioned service; nearly a quarter of Kenya's Safaricom subscribers use this service to purchase songs with which to customize their phones' ringback tones (heard by the caller while awaiting an answer). Some women said they like Skiza Tunes; the majority, however, felt that it was just another service that ate away at their airtime, and for which unsubscribing was a near-impossibility. In one woman's words:

> I have songs, how do I remove them? When I put money it goes, when you borrowed the song. All those things they deduct money. When you hear, they are singing good, oh what is this? And money goes.

Subscribing to these services is easy, and exploits some people's familiarity with short codes. Safaricom advertises Skiza tunes through multiple channels, all of which include instructions on how to join: e.g., PCM messages have Skiza ads, and people who call Skiza subscribers are told to dial 11 if they like their friend's song and want

it for themselves. Significantly less visible are the instructions on how to unsubscribe, and the fact that Skiza's cost is automatically deducted from the subscribers' available airtime. During our initial group interviews, women begged us for information on how to remove these services from their phones, for example:

> That business in the phone it cannot be removed (. . .) that business is with Safaricom and it continues. Is there a way of removing them? Can you remove those services, so that they do not deduct money, is there is a way?

Perhaps Florence's experience best illustrates this problem. We gave respondents scratch cards with KES 100 of airtime. After she entered her serial number, she announced that she had KES 4 of airtime. Perplexed, we looked at her handset and learned that she was subscribed to five Premium Rate services, and had been KES 96 in debt. The loss of airtime to pay off debt was a common occurrence, and—as has been argued in other research—shows the need for greater price transparency, and for interfaces that clearly indicate to users how much airtime is being deducted when they are using mobile services [Sambasivan et al. 2013]. Unsubscribing was difficult for many more people than just our rural interviewees, as shown by multiple posts on Safaricom's official Facebook page, such as the following:

> Kindly Help. . . . How does one unsubscribe from unsolicited text services. . . I am suffering, every morning I wake up, I have received two texts of some songs and message of sorts and each is Kshs. 30 bob. . . . I have tried to send STOP but it's not working. . . .

After identifying this as a problem during our September research trip, we developed a short video clip that demonstrated how users could unsubscribe from Safaricom's Premiums Rate services. The cumbersome and USSD-protocol-based process involves entering a short code, navigating five different menus, answering queries by inputting a number, scrolling to the bottom of menus, translating unfamiliar terms (i.e., "Selfcare" and "International Voice Bundles"), and selecting an option that provides no feedback to confirm that users have actually unsubscribed.

Understandably, losing credit bothered respondents, and some tried to contact Safaricom's free customer service hotline in hopes of getting a refund. However, the line was often busy—a common source of dissatisfaction with Safaricom, as reported in prior studies [Morawczynski and Pickens 2009]—and promised refunds were never actually received.

5. DISCUSSION

Motivated by widespread mobile phone ownership in Kenya and other developing countries, technologists in HCI and ICTD continue to develop mobile applications and services meant to benefit marginalized populations, such as the rural women we studied. To our knowledge, none of these applications have reached the scale of use that Safaricom's services have; our findings reveal important antecedent conditions that technologists must consider if a mobile application is to become widely adopted. Efforts to foster communication between women and healthcare providers or nighttime escorts (i.e., Hagan et al. [2012] and Perrier et al. [2015]) showcase ICT's potential; however, if women struggle just to add airtime to their handsets, it is unclear how they can take advantage of such services. Rather than providing marginalized populations with income-generating opportunities (as exemplified by mobile applications like txteagle and mClerk [Eagle 2009; Gupta et al. 2012]), the opposite can happen: services can result in users losing money, and thereby, amplifying existing forces—specifically, the continued profits of network service providers. Furthermore, while Kenya's urban

elite may be benefitting from owning a mobile phone and from Safaricom's services, these applications do not appear to build upon rural users' capabilities and mobile use practices: instead of sending text messages, the women in our study typically used their phones to enter the short codes necessary to send friends or relatives PCMs, or to make/receive voice calls.

6. TECHNOLOGISTS' RESPONSIBILITIES FOR WHAT THEY BUILT YESTERDAY

Dourish and Mainwaring ask technologists to consider "(their) ongoing responsibilities for what (they) built yesterday" [Dourish and Mainwaring 2012]. While technologists have been quick to embrace the mobile phone as an ICT that can benefit the poor, there has been far less attention devoted to the problems inherent in these devices' design. The design of existing mobile phones and their accompanying services (that were "built yesterday") do not match the skills, expectations, or needs of their intended users, and in fact may negatively amplify existing inequalities. While we do not want to suggest that design alone can address the inequalities we observed in our study, our findings do point to an important role for HCI in developing interfaces that are better aligned with rural users' capabilities. We encourage researchers to revisit the foundational and fundamental ideas in HCI, and "to 'improv(e) human–computer interaction by improving the 'usability' of computer interfaces" [Grudin 1992], in order to limit the effects of differential capacity in further disadvantaging rural users.

Women in our study frequently experienced difficulties using the mobile interfaces on the phones they owned. Alternatives to the PIN-based authentication methods—which were largely developed for urban users and those living in industrialized nations—would also be useful projects for HCI researchers to pursue. HCI researchers' efforts to design interfaces for people with poor visual acuity—in particular, older adults—are common in developed countries (e.g., Kane et al. [2009], Kurniawan [2008], and Kurniawan and Panayiotis [2005]), but there are currently no attempts to design mobile interfaces that would accommodate the high prevalence of presbyopia in rural Kenya. Rather than being deeply embedded inside the phone, M-Pesa should be easily accessible, marked with a consistent icon that users can understand and remember. Applications that our participants told us they had little need of (i.e., Memos, Currency Converter, and Stopwatch) should be removed from phone menus, or at least not be featured at the beginning of them, so as to minimize scrolling [Medhi et al. 2011]. Unsubscribing from Skiza Tunes, and other services that deduct airtime should be as straightforward as subscribing; if this is not possible, then perhaps Safaricom should reconsider marketing these services to low-income and novice mobile phone users.

Error messages that are specific and designed for intended users are necessary. This means not only providing local language support for error messages (as others recommend [Medhi et al. 2011]), but also creating messages that acknowledge peoples' linguistic practices. For example, our participants rarely spoke (or sent texts) in only one language at a time, instead combining elements of several distinct languages. As has been suggested by other researchers [Bidwell 2016], our findings support continued efforts to reconsider the mobile graphical interface, and to instead amplify peoples' existing practices by developing voice services. Finally, Safaricom's announcement in September 2015 that they will make their M-Pesa's application programming interface publicly available is encouraging [The Daily Nation 2015] and means technologists can work to develop applications that are operable with other mobile money systems (i.e., Airtel Money). Efforts to reduce Safaricom's dominance and promote competition between Kenya's mobile network providers may positively benefit rural populations [Zuckerman 2010].

Asking technologists to be responsible for what they built yesterday also means investigating how HCI researchers can transfer their research findings to industry; in

other words, it is necessary to encourage mobile phone manufactures to implement the insights in this and other HCI studies (i.e., Medhi et al. [2011] and Sambasivan et al. [2013]). To date, handset manufacturers have not implemented recommendations from these studies, and findings from our research suggest navigating hierarchical menus and scrolling, in addition to monitoring mobile airtime balances continue to hinder mobile phone use [Wyche et al. 2016]. Thus, in addition to expanding the community's focus beyond invention and intervention efforts, we also hope our research stimulates discussions about how to amplify the role of HCI in Safaricom, or to focus on "build(ing) human forces that are aligned with your goals"—Toyama's rule for amplifying people. iHub (the Nairobi-based technology innovation center) UX lab's efforts to introduce Kenyan software developers to HCI (see: https://www.ihub.co.ke/uxlab), provides an example of how to do this, efforts to amplify our respondents' voices in the design process would also be beneficial.

Finally, we recognize that merely implementing these design changes will not be enough to address the inequalities we observed, or to remedy the underlying issues (e.g., incomplete rural electrification, and lack of access to corrective lenses), which contribute to our respondents' problems; however, we do believe that good design can help to achieve the "balanced progress" Toyama [2015] encourages.

Understanding the Uneven Power Relations Embedded in Mobile Applications Development in HCI and ICTD

Irani et al. argue, "The potential consequences of bringing resources and people in line with the interests of powerful capital and commercial actors" *must* be "recognized and analyzed in ICT4D literatures" [Irani et al. 2010]. We agree and our findings demonstrate why this recognition and analysis is important, and raise important questions about largely overlooked factors in HCI and ICTD research, such as: who pays for the applications? How will they generate the revenues necessary to remain sustainable? How will they be marketed? How can users trust that they are not yet more useless airtime-squandering services? Will users be able to unsubscribe? Who will offer technical support and answer usability questions? These questions merit more research attention, as overlooking them may undermine technologists' hopes for their well-intentioned mobile phone applications to succeed.

Continued efforts to understand the ways for-profit corporations and the technologies they develop amplify inequality are needed, especially now as that U.S.-based companies (i.e., Facebook and Google) devote more and more resources to "connecting the whole world" [Zuckerberg 2013]. In particular, it is important to understand who benefits more from Internet access: the billions of people who (like most of our study's participants) were not previously connected to the Internet, or the corporations. Finally, discussions are necessary about the morality of companies such as Safaricom generating exorbitant profits while so many of their customers live in poverty. It is also necessary to recognize the challenge of designing scalable mobile services that both benefit marginalized populations and satisfy corporations' profit motives.

7. LIMITATIONS, FUTURE RESEARCH, AND CONCLUSION

The laws of amplification are powerful, and can be used as a lens for examining rural women's interactions with their mobile phones and with the design of Safaricom's products and services. Our findings provide a counter-narrative to the mostly optimistic stories about the possibilities of widespread mobile phone ownership throughout sub-Saharan Africa and draw attention to flaws inherent in the design of these devices. We provide some evidence suggesting ways mobile phones amplify existing inequality between rural and urban users, and—more broadly—between for-profit companies and marginalized populations.

A number of limitations should be kept in mind when interpreting our results. While purposive sampling was used to select people who represented a variety of opinions, the full range of views and beliefs may not be reflected. In addition, data were collected by an "outsider" researcher, with the aid of Swahili and Luo translators; this likely influenced the nature of the information respondents shared [Dell et al. 2012]. This was a qualitative study, and the findings cannot be generalized beyond our sample; however, they provide new perspectives on insufficiently studied constraints affecting mobile phone use in rural sub-Saharan Africa—constraints, which are most likely not unique to the women we encountered.

Moving forward, we will assess whether or not videos are useful for teaching rural residents how to use their mobile phones. The second and third authors continue to meet with our respondents and answer their questions about how to use their handsets. There is an opportunity for more systematic research examining the services described in our paper—specifically, efforts to quantify how much money rural Safaricom users lose because of poorly designed services. Finally, we also plan to investigate how the design of U.S.-based network providers' applications and services may result in their customers losing money.

In conclusion, our goal is not to criticize intervention efforts in HCI/ICTD; indeed, we recognize that pitting technologists versus social scientists is unfruitful for researchers who are collectively interested in exploring the role technology can play in improving people's lives. Instead, we encourage more discussions (and collaborations) within the community that recognize the design tradeoffs that are necessary for developing services to reach scale, and continued reflection on the critical differences between rural low-income people and the private sector. By more fully understanding users, technical constraints, and for-profit companies' design decisions, we hope to make discoveries that have positive impacts; doing so demands greater patience, collaboration, and a deeper understanding of the populations using these technologies.

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