Crowdsourcing Subjective Fashion Advice Using VizWiz: Challenges and Opportunities

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ABSTRACT
Fashion is a language. How we dress signals to others who we are and how we want to be perceived. However, this language is primarily visual, making it inaccessible to people with vision impairments. Someone who is low-vision or completely blind cannot see what others are wearing or readily know what constitutes the norms and extremes of fashion, but most everyone they encounter can see (and judge) their fashion choices. We describe our findings of a diary study with people with vision impairments that revealed the many accessibility barriers fashion presents, and how an online survey revealed that clothing decisions are often made collaboratively, regardless of visual ability. Based on these findings, we identified a need for a collaborative and real-time environment for fashion advice. We have tested the feasibility of providing this advice through crowdsourcing using VizWiz, a mobile phone application where participants receive nearly real-time answers to visual questions. Our pilot study results show that this application has the potential to address a great need within the blind community, but remaining challenges include improving photo capture and assembling a set of crowd workers with the requisite expertise. More broadly our research highlights the feasibility of using crowdsourcing for subjective, opinion-based advice.

Categories and Subject Descriptors
K.4.2. Social Issues: Assistive technologies for persons with disabilities

Keywords
Crowdsourcing, Blind Users, Fashion

1. INTRODUCTION
The language of fashion has been studied for decades and has philosophical and historical roots. *The Psychology of Fashion* states "Fashion is nothing more and nothing less than the systematic encryption, transmission, and interpretation of social meaning. A fashion item itself is only a vehicle that transports cultural information to its destination – the consumer" [17]. Other books present a more practical self-help view such as the seminal book *Dress for Success* where readers are told the book's information will "make you look like a million so you can make a million" [11]. Though one may not believe they can become rich simply by dressing a certain way, the book's title is now engrained in American culture and a generally accepted idiom.

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Our clothes can communicate details about ourselves to others. A punk rocker communicates rebellion, pink ruffles communicate feminine youth, and hats or scarfs worn a certain way can communicate gang affiliation. But impressions from clothing are made by visual evaluations, thus making it greatly inaccessible to many people with vision impairments. This means basic information is not available such as uniforms distinguishing police officers and doctors, and more subtle nuances may be missed such as not adhering to a restaurant's dress code and being subjected to social embarrassment.

Because most people they encounter will see and evaluate what they have on, people with vision impairments must find ways of learning about fashion nuances even if the information is not something they readily comprehend. For instance, as one writer for the National Federation of the Blind tells parents in her article, "Then your child ought to be learning that stripes and plaids--whatever those are--don't go together…" [15]. People with vision impairments must also find ways of overcoming the obstacles clothing and fashion present. This includes a heavy reliance on the assistance of sighted companions and low-tech solutions such as tagging clothes with safety pins [10]. Though there are means of coping with limited clothing information, technology can play a large role in addressing and alleviating many challenges.

In this paper we describe a 10-day diary study exploring fashion perception among those with vision impairments which identifies many clothing-related accessibility barriers [4], as well as discuss an online survey we conducted to learn how individuals with and without vision impairments get fashion advice. We present related work on accessible fashion and crowdsourcing [7] (the technique we propose for addressing some of the accessibility issues). We then present a pilot study using VizWiz [2], a mobile phone application for people with vision impairments, to test the feasibility of having sighted people answer subjective fashion questions. We conclude with a discussion of our results, and how our findings can be used for other applications of crowdsourcing subjective information.

2. PRELIMINARY INVESTIGATIONS

2.1 Diary Study on Fashion Perceptions
Our research began with a diary study that explored the question "How is fashion perceived when one is blind or low-vision?" [4] Our focus was on understanding how those with vision impairments make and communicate fashion choices, how the fashion choices of others are communicated to them, and how other senses influence aesthetic perception.

2.1.1 Study Methodology
We recruited eight female participants (no males responded to the study announcement) who were all legally blind (visual acuity 20/400 or less). The participants were diverse in age (21 to 73

years, average 37.25), vision impairment (ranging from low vision to total blindness), and in clothing style (in terms of how they dressed and approached clothing decisions).

We first conducted one-on-one interviews with our participants for one hour (primarily conducted in their homes, two were conducted in their workplace). After the interview we asked them to type diary entries for the next 10 days. To help them get started we told them to begin with what they wore that day and how and why they chose it, but then explained we wanted them to write about anything else they felt was relevant to the study. After completing their diary, we did short phone or email follow-ups. (Two participants did not complete the diary and one completed only seven days.)

2.1.2 Results: Fashion Concerns and Challenges

From this study we found that there are numerous areas of assistance needed by those with vision impairments. We organized our findings from the diary study into two categories - *objective* information such as color, size, and washing instructions, and *subjective* information such as whether items coordinate and whether an outfit is age appropriate. We are exploring technologies to address both the objective and subjective areas but the main focus of this paper is the many subjective aspects of clothing that are inaccessible. Because understanding these nuances requires seeing what others are wearing and having a visual understanding of which clothes fit into certain categories, these areas of fashion presented numerous, even stressful, challenges for our participants.

All of the participants mentioned they simply desired to "fit in" but they could not see what others were wearing to know the latest fashion trends. They mentioned that having white canes and guide dogs made them stand out in an undesirable way and they did not want any other undue attention. This desire to fit in is similar to the analysis of body image and stigma among people with physical disabilities such as in the work found in [19].

Participants also mentioned not readily having access to "flaws" in their attire such as fading, wrinkles, or stains. They recounted how people who saw these flaws in their clothing in turn often looked upon them with pity (a scenario four participants dubbed "poor blind girl"). They felt the person was making a judgment of their inability to be an independent person simply because they could not see this aspect of their clothing.

When asked how they overcome clothing obstacles, participants explained that they rely on the assistance of sighted companions (and even strangers), which was limiting in many ways. One participant, for instance, lived in a remote area where only her sighted husband was available to help her shop, which she knew was not ideal because he did not shop like a female would. Because of this she limited her shopping to stores where they sold outfits that are already coordinated or are only black and white. She also limited her wardrobe to the same clothing combinations (outfits) and did not mix and match her clothing. Another participant had recently moved across country and had not yet made enough friends to have a corpus of people to assist her, thus forcing her to rely mostly on the salespeople who didn't know her and could be motivated simply to make a sale. Yet another participant shopped at yard sales and consignment shops for bargains but was then left without a salesperson to ask and only had a few family members with whom she shopped.

When asked if there were technologies that could assist with clothing decisions, the only device our participants mentioned was a color identifier. The participants who used the device (only two out of the eight) realized it was limited in its function such as not identifying patterns and misrecognizing certain colors, and mostly used it simply to distinguish clothes that did not have tactually discernible features and were easily confused. No other technologies were mentioned yet participants welcomed the idea of using any technology that could help.

The numerous accessibility challenges expressed by our participants led us to further explore how technology could be used to solve these issues. Intrigued by the idea of using crowdsourcing as one solution we conducted a follow-up online survey to understand how people currently make clothing decisions and to specifically ask how they confer with others.

2.2 Online Survey on Clothing Decisions

We conducted an online survey to understand how people make clothing-related decisions and identify where technology could better assist where there are challenges. The questions did not ask about specific technology solutions; rather we used the results to shape and confirm our ideas and identify potential requirements. Because of the benefits of universally accessible design and deploying technology to widely used devices [14,16], the survey was open to anyone, that is, people with and without disabilities.

Twenty-two adults (11 female) completed the survey, with a majority (16 of 22) between ages 25 and 54. Seven men and two women reported they had some form of vision impairment but we did not record details about their visual ability.

Our participants reported that shopping is a collaborative event regardless of vision ability. For instance, when asked about shopping in a retail store, only two participants (both without a visual impairment) said they shop alone. The remaining participants all shop with companions (family and friends) and most ask those companions for opinions and help finding an outfit. Less than half the participants said they would ask these same opinion questions of the salesperson; however, the percentage of participants with vision impairments that would ask the salesperson's opinion (66%) was higher than those without vision impairments (33%), as was indicated by our diary study participants when describing retail shopping experiences.

We asked participants if they confer with others for special occasion outfits such as an interview or date. We assumed people did not confer with others everyday but would more likely do so for a special event. For the 13 participants who stated "yes" we then asked how they felt about those people – did they have a good core set, want more people, and/or want different people? Participants without vision impairments indicated they had a good core set (6 out of 7) with only one person desiring to have different people to ask. But those with vision impairments wanted more people (5 out of 6) and different people (3 out of 6) with whom they could confer about clothing decisions.

We asked participants to rate their interest in having certain clothing information on a scale of 1 (very interested) to 4 (don't need). Figure 1 shows the total of "Very Interested" and "Somewhat Interested" ratings for all participants for the items listed in the question. The most desired information need was how items in one's wardrobe coordinate, with participants with vision impairments unanimously interested. The only item that was not popular among participants with vision impairments was "knowing when and where I wore something" (only 2 participants indicated they were "Somewhat Interested"). Other responses participants wrote in included knowing if there were stains or

imperfections on their clothes, if something was appropriate for the occasion, the type of image/impression being projected by an outfit, and advice on how to dress for a certain body type.

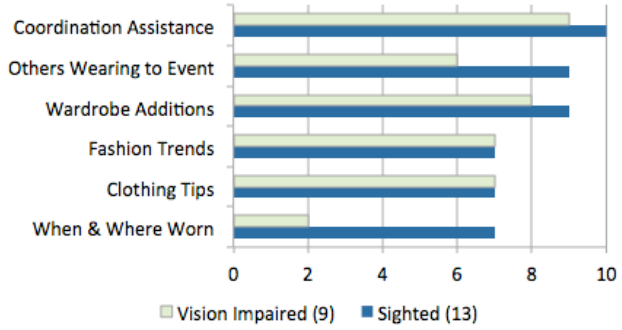


Figure 1 - Clothing information participants would like to have available

From this work we explored the current landscape of accessible fashion for people with vision impairments as well as current collaboration technology for clothing. As we describe in the following related work section, current research and available technologies do not fully address our participants' requirements.

3. RELATED WORK

3.1 Fashion and Assistive Technology

Many new assistive technologies for those with vision impairments are being embedded in clothes such as jackets, shoes, and glasses to assist with object detection [1,3,18]. But these devices are simply using clothes as the shell for the technology, not addressing fashion needs or being designed as fashion targeted for those with vision impairments.

Color identifiers are often used to help identify clothing color -- a fundamental accessibility barrier described by our study participants. Unfortunately, color identifiers (both hardware and software) are reported to have low accuracy rates and are not able to identify patterns [9]. Also, these technologies focus solely on color identification and do not address related clothing nuances such as what other colors will coordinate with the one identified.

There are limited resources to learn fashion nuances, and the current solutions are either impersonal or expensive. Television shows such as *What Not to Wear* help contestants purchase entire new wardrobes based on the advice of stylists (a show two of our diary study participants mentioned watching) [22]. But since the show's medium is television, important visual cues may be missed. There are also many personal stylists that one can hire, including those from a company co-owned by a *What Not to Wear* co-host, but this can be very expensive [23]. There existed a free iPhone application where a person could send a clothing photo and question to a stylist, very similar to our approach using VizWiz [5]. However, our focus is answers from non-experts, a larger and more available population pool. Also, this application is no longer available as the company has been acquired.

As mentioned by our first study's participants and confirmed in our research, there do not appear to be any products that serve as assistive technologies to aid with making clothing decisions and learning about fashion. Though there is promising computer vision-based research to improve automated color and pattern identification and matching as in [21], this technology is not yet commercially available and does not fully address the subjectivity of deciding what it means for items to match. Currently there is a heavy reliance on those who are sighted to assist with these topics, which can be very problematic since a sighted person may not always be available or be a reliable source. Thus our goal is to develop technology that can help connect people to answer complex fashion questions.

3.2 Gathering the Opinions of Others

When desiring a second opinion, many individuals turn online. Websites such as fashism.com let people give opinions on others' fashion choices, but may be difficult to use for those with vision impairments [24]. For instance, fashism.com requires a picture be uploaded and vision-impaired users generally cannot ensure the photo is clear and focuses on the correct items [8]. On fashism.com they will not receive feedback on their photo; it will simply be posted and analyzed as-is. The responses on fashism.com are limited, as they only support thumbs up/down voting with the option of writing in content (but the majority of responses do not include comments). With so many users and new posts each day (adding up to hundreds of photos to view) there is no guarantee of a response. Lastly, the system is open to the public, which presents the potential issue that people who cannot see their outfits and are not confident in how they will be perceived may be reluctant to share them with thousands of strangers for approval.

There may be an inclination to simply use a social networking site such as Facebook. But depending on the user's settings this also may not be a private venue and if the person is not sure of how they look in an outfit they may be hesitant to post this to a site of acquaintances and colleagues for feedback. Users may also feel they can only ask a certain set of questions or a limited number to avoid the impression that they are helpless because of their disability or the feeling they are bombarding (and annoying) their network. There is also the issue of Web accessibility as many people with vision impairments surveyed about website accessibility listed Facebook in their top ten sites to avoid [20].

There is a need for accessible technology that brings people together in a private, closed setting to address clothing questions that are difficult for a machine to interpret. For instance, detecting stains on clothing would require very sophisticated computer vision techniques, but can be detected easily by a human (though it would be potentially embarrassing to bring up in an open environment). Also, as noted in our online survey, there is a desire to have multiple opinions to answer clothing questions.

Past work has demonstrated that people are willing to use a social network for recommendations and opinions. In an investigation of what questions are asked on social networking sites, Morris, et al found that 29% of their participants' questions asked for recommendations and 22% for opinions [12]. Also, there is work that demonstrates people responding to inquiries when using crowdsourcing [7] do not have to be subject matter experts. In [13], Morris and Picard used remote workers to give participants responses equating to that of a therapeutic treatment for helping relieve stress. This past work on non-experts successfully helping remote people sets a positive precedent for our desired system which aims to send questions to people who are not fashion experts and have them answer subjective, opinion questions. Taking the best of social networking and crowdsourcing and concentrating it on this area seems to have great potential and promise. In the next section we describe how we used the iPhone application VizWiz to test the feasibility of crowdsourcing subjective fashion questions.

4. CROWDSOURCING FASHION ADVICE

4.1 Study Methodology

We conducted a two-week pilot study to test the feasibility of crowdsourcing clothing-related questions, users' trust of the volunteers ("trusted strangers" [6]), and the overall usefulness of the system.

4.1.1 VizWiz Prototype

VizWiz is an iPhone application that provides users with nearly real-time answers to visual questions [2]. Users can take a photo of an object in their environment (such as a thermostat or bottled water); record a question about the object (such as "What is the temperature reading?" or "What brand is this?"); and send the question to a bank of volunteers, Web workers, members of their social network, or to IQ Engines (computer vision program) [25]. Answers are returned almost immediately to the users as a written message that can be displayed with the phone's screen settings for low vision users or read aloud using the built-in screen reader.

If the user selects the "Web workers" source, their question will be answered either by a designated volunteer associated with the VizWiz project (if one is online and available at the time) or by "turkers". "Turkers" refers to people from around the world who have signed up for Amazon's Mechanical Turk ("MTurk") service and are available to complete short tasks on their computer for a small amount of money practically 24 hours a day, seven days a week [26]. Because these workers are always available and a vast majority are sighted, the visual questions asked by VizWiz users can be answered with great accuracy and with an average turnaround time of 90 seconds.

Building upon the success of VizWiz, we hypothesized that this system could be useful in giving users advice on clothing and fashion-related questions. Our goal with this pilot study was to capture data on the feasibility and usefulness of this application in addressing primarily subjective questions about the visual medium of fashion.

For the pilot, users downloaded the VizWiz application currently available in the Apple App Store. Questions were sent to designated volunteer workers for responses. Since we are attempting to address subjective information that would be outside of the realm of computer vision, IQ Engines wouldn't serve our needs. And though we do not entirely discount using a service such as MTurk, we recognized that the responses needed to be appropriate culturally and Web workers live around the world where widely varying fashions exist (for instance, the public fashion of Al Qassim, Saudi Arabia and Miami Beach, Florida are vastly different). Also, we needed to ensure the answers were tactful and constructive and not insulting or insensitive. Lastly, we believe the interactions need to occur in a private and more secure setting since the questions may be sensitive. Future studies should incrementally test for these aspects, however this pilot focused on the feasibility of designated remote workers who are not fashion experts dispensing subjective fashion advice.

4.1.2 Study Participants

Through convenience and snowball sampling (including posts for the study on relevant email lists), we recruited three men and four women ages 27 to 59 (average 44 years). Participants were required to be over 18 years of age, have an Apple device compatible with the VizWiz app (iPhone, iPad, or iTouch), and be legally blind (visual acuity 20/400 or less). Most participants indicated they were "totally blind" (presumed to be complete vision loss) with one participant having a degenerative vision impairment. Table 1 shows the details of each participant. All of the participants lived in the United States except Participant 2 who lived in the United Kingdom. Given our sensitivity to culture playing a role in fashion we informed him that we were in the United States and he confirmed he was comfortable receiving advice from people in the United States.

#	Gender	Age	Description of Vision Impairment
1	Female	27	Blind
2	Male	34	Blind
3	Male	38	Blind
4	Female	46	Blind
5	Female	48	Retinitis pigmentosa
6	Male	57	Blind
7	Female	59	Blind

Table 1– Description of participants in study to evaluate feasibility of crowdsourcing fashion advice through VizWiz

4.1.3 Trusted Strangers

In prior research on designing a social network to support the independence of young adults with Autism, researchers explored the concept of "trusted strangers" [6]. They were investigating how social media could extend the person's network from family, friends, and close professionals to "people who are willing to commit their time to help the individual…and give the individual trustworthy feedback". These goals are very similar to ours in wanting to extend the network of people asked for fashion advice.

In an effort to study the feasibility of "trusted strangers", we initially only told participants that there were volunteers available to answer their clothing-related questions (not indicating the number of volunteers). At the start of the second week they were emailed descriptions of each volunteer that included their gender, age, and clothing style (see Table 2).

Volunteer Worker Descriptions
Volunteer 1 is a female recent college graduate who has a youthful, casual style that includes the latest fashion trends.
Volunteer 2 is a female young adult with a classic sense of style who loves to dress up even though she's allowed to dress down for what she does.
Volunteer 3 is a female recent government retiree whose style is professional, sophisticated and conservative.

Table 2 – Description of the volunteer workers sent to participants in Week 2

The three volunteer workers included two researchers and a family friend. They were available to answer questions from 8am to 9pm Eastern Standard Time. Participants received at least one answer to every question, but if multiple volunteers were online at once then they would receive responses from everyone online at the time.

4.1.4 Data Gathering: Daily and Weekly feedback

Participants were asked to use the system as they saw fit throughout the two-week period. They were not given a minimum or maximum number of questions to ask, in an attempt to simulate real world usage. Participants were asked to provide daily feedback in the form of either an email or voicemail where they gave a general synopsis of their experience using the application that day, or the reason for not using it. This was used to capture fresh impressions of the interactions and build a richer set of data.

At the end of each week the participants were asked to fill out a survey giving feedback about their use of the system. For each

survey we collected demographics including age, gender, and nature of their vision impairment. All questions, including demographics, were free-form text area responses.

For the first week, survey questions focused on the following:

- Timeliness of responses and desired wait time
- Alternate sources of gathering clothing information
- Ways in which the responses were confirmed
- Levels of trust of the workers
- Overall usefulness
- Questions they would not ask in the application

Since participants were given more information about the volunteer workers during the second week, the second survey focused on how their knowledge of the volunteers affected their satisfaction of the system as well as their final feedback.

For the second week the questions included the following:

- Effects of having volunteer descriptions
- Other desired volunteer information
- Preferences for volunteers with same demographics
- Desire for volunteer information if app made public
- Comparison of volunteer responses to peers
- Time for picture preparation
- Overall usefulness
- Suggested improvements and final comments

4.2 Findings

4.2.1 Types of Questions Asked

During the study we received 93 questions total, 77 of which were fashion-related. The excluded questions were primarily about non-clothing items (e.g., identifying a bottle of medicine), tests made to confirm the participant was in the study, or questions submitted either to report an issue or test equipment (e.g., testing the camera because it was not previously working).

Among the valid fashion questions, Figure 2 summarizes their categories. Questions labeled "Visual (Objective)" include questions such as "Can you please describe the shirt?" and "What does this shirt say?" Questions labeled "Fashion (Subjective)" include questions such as "Can I wear these two pieces together?" and "Can this sweater work with business attire, as well as more casual outfits?" Questions labeled "Both" include "Could you please tell me the color of this pair of pants and shirt, and whether they coordinate well for a business casual occasion tomorrow?" One fashion question was excluded from this analysis because the clothing photo came through but no audio.

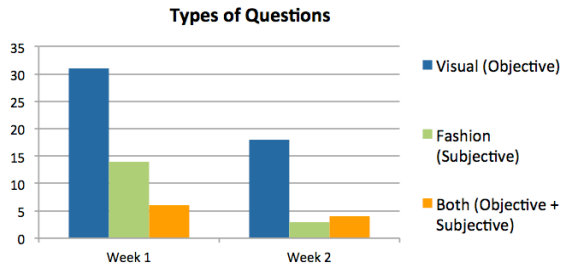
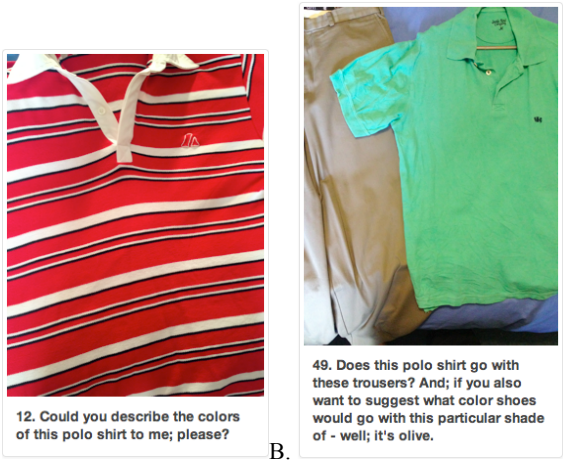


Figure 2 - Most questions during the study asked for objective information such as identifying color

Overall we noticed a certain strategy and progression among the majority of participants. As a first step, participants wanted to get a feel for taking photos and the necessary lighting as well as what answers they would receive from the volunteer workers. They asked questions to which they already knew the answer (as they stated in their daily feedback) to test whether the volunteer workers would respond as expected. These validation questions were very basic, such as "What color is this?" (Figure 3A)

By the middle of the first week the questions became more frequent and complex and included more queries about matching, the appropriateness for certain occasions, and even creating entire outfits, such as one participant asking what shoes should be worn with the clothes shown (Figure 3B). Participants commented in their feedback that they began to feel more comfortable with what they were willing to ask and even gained ideas on what to ask based on the responses. For instance, after just the first week Participant 4 wrote in her survey "It grew and stretched my thinking about clothing."



A. B.

Figure 3 – Example of basic question asked early in the study (A) and advanced question asked later in the week (B).

One unexpected question we received asked about the appropriateness of a companion's outfit (Figure 4). The fashion choices of those with whom you associate can be almost as much a reflection on you as your own wardrobe. This is especially true for parents and guardians who need to be cautious of what their children are wearing (similar to Figure 4).

Figure 4 - A grandfather asks the volunteers about the appropriateness of his grandson's shirt

Only seven of the photos were taken while the person was wearing the clothes in question. Of those, two specifically asked how they looked in the garments. In these instances the volunteers

were able to not only advise the person on the color and style but also about fit and body type. For instance, one user asked how she looked in a pair of pants and was given advice from two volunteer workers that they were not visually flattering because the tapered leg on the pants did not suit her figure.

4.2.2 Building Trust with Helpful Responses

As mentioned, we wanted to gather data on how participants felt with people they did not know (strangers) answering questions the participants could not confirm for themselves. In the second week's survey we asked how participants felt about receiving descriptions of the volunteer workers. Participants 2 and 7 said it was helpful, Participant 1 said it was "interesting but it did not change my use of the system," and the other participants stated it had no effect. (Note: Participant 6 did not complete the final survey.) When asked if they would like to know more about the volunteers, Participant 7 was the only to write a detailed response:

> "Yes, I would like to know if the volunteer preferred 'big city' or 'small town' style of dress. Also, I would be interested to know if the volunteer had exposure or experience with various other cultures. Like color preferences and accent pieces for a complete look." *[Participant 7]*

Participants 5 and 7 also had preference about the volunteer having the same demographics as theirs. Participant 5 said it would be nice if the person were in the same age range and possibly also be a fashion expert. Participant 7 said they would like someone of the same culture, though not exclusively.

Though it seems the descriptions of the volunteers was helpful and useful, overall it was not what helped the users get more comfortable with using the system. Participant 5 expressed a sentiment in the survey that seemed to be a theme of the other survey and daily feedback:

> "What truly changed how I used the application was the confidence I had using it. I became much more confident with the answers the more I used it." *[Participant 5]*

Throughout the study the daily feedback was often praise for the responses received from the volunteers with sentiments such as "impressed" and "good as usual". Each volunteer worker made sure they responded with as much detail as possible and even gave advice beyond what was asked. For instance, if someone asked if two garments "matched" they might have also received feedback about other general items that would coordinate with the garments (or coordinate better). One participant asked if a certain tie and pant combination would work well with a white shirt and was given advice that, yes, it would coordinate but look even better if he also wore a black blazer. The continual cycle of helpful feedback seemed to be what made users trust the system, not necessarily knowing who was sending the feedback.

In the first week's survey participants were explicitly asked if they trusted the volunteer workers upon first using the system and then if their trust increased, remained, or decreased if they used the system frequently. While others simply trusted the volunteer workers outright from the start (either from prior VizWiz experience or general trusting of sighted volunteers), Participants 5 and 7 (among the most active when giving feedback about knowing the volunteers) admitted they were hesitant but the responses increased their trust.

> "I was hesitant at first. The more I used the application the more I trusted the workers. Also having sighted confirmation of the results helped." *[Participant 5]*

Participant 6 did comment in this first survey that they might be more hesitant with a publicly available service, however, confirming our hesitation to open the service to Mechanical Turk.

> "I assumed that anyone entrusted to be a volunteer was trustworthy. If we move to a community of unscreened volunteers, this could be an interesting problem." *[Participant 6]*

Interestingly, after receiving the first survey one participant emailed one researcher with a question. She explained that the question about trusting the volunteers seemed odd to her because she had always assumed that people without a color blindness condition agreed on clothing and there was no subjectivity. She wanted to know if she should be clarifying in her questions whether she wanted to know "facts" versus "opinions". We reserved answering her question until after the study to prevent influencing how she used the system but later explained that clothing is very subjective and that some colors are difficult to distinguish even without color blindness. We believe this feedback reveals an important perspective in trusting strangers.

Also in the first week's survey participants were asked if they received external confirmation of their answers. We asked this because answers to subjective fashion questions carry more weight when they are externally validated, and we believed this would impact whether or not they trusted the volunteer workers. One participant did not answer this question (mentioning instead a technical issue) but the other six indicated "yes" with one giving the following anecdote:

> "Yes, I did get confirmation of the answers I received. I attended a Professional Workshop […] and several of the attendees commented on my attire. I also got an affirmative from my sister who I just happened to run into. And without, my even asking, she commented on how nicely I was dressed." *[Participant 7]* (Portions removed for privacy)

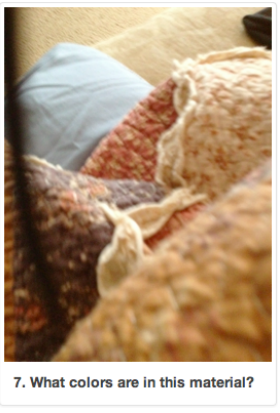
4.3 Challenges

4.3.1 Taking Photos

As with the current instance of the VizWiz application [2], many of the responses and exchanges with users involved assisting them with taking better photos, an obvious caveat of the application. Understandably, users can get frustrated if they have to make multiple adjustments for a question to which they need quick access (or worse if they can never receive an accurate response). For now, however, photos are the most efficient means of remotely sending visual questions to a crowd of respondents so we will continue to monitor outcomes of other blind photography research such as [8] to improve these capabilities.

There were many obvious instances of participants needing to adjust their photos (such as if the photo was all black), and times when the need for modifications was not so easy to detect (Figure 5). The photo on the left (Figure 5A) was given a response of "gray" but the participant stated in their daily feedback they were anticipating "blue" and that let them know they needed to change where they took photos. In the photo on the right (Figure 5B), two volunteer workers gave conflicting responses on color (identifying brown, tan, and *red* vs. brown, tan, and *dark orange*) causing confusion for the participant who actually sent the same question again but received the same responses.

A.



B.

Figure 5 – Color questions misidentified by volunteers due to lighting, answering gray when blue was expected (A) and conflicting responses of red and dark orange (B)

4.3.2 Volunteer Coordination

There were a few instances where participants experienced a very long wait for their response because there was no volunteer available to answer their question. Aside from constantly calling or emailing one another, there was no mechanism to ensure that at least one volunteer was online during the 8am to 9pm window. Thus, there were periods where each volunteer went offline, but the other volunteers did not know. This greatly effected how the participants perceived the system. In the first survey we asked participants what they felt would be an acceptable wait time and the responses ranged from 59 seconds to 30 minutes. Four of the seven participants said five minutes and the average of their responses was just over eight minutes.

5. DISCUSSION

Through the feedback we received from our participants we have shown that users are comfortable asking subjective questions to strangers and trusting those responses. There are some questions participants reported not feeling comfortable asking including questions related to undergarments and weight. Nonetheless, many participants said they were comfortable asking anything.

When photos were taken while wearing the clothes in question, the volunteer workers' responses were sometimes different than they would have been if the clothes were only laid out. Realizing it takes more time and effort to take this type of photo and that some users may not be comfortable doing this, we do not think future fashion systems should require users to submit these photos but it may be worth emphasizing to users that their responses may be different when a garment is on their person.

There are certain instances where misidentifying color may always be an issue. Computer screens may render color differently and even in-person in bright daylight people often mistake certain colors such as navy blue for black. It may therefore be helpful to keep a repository of colors that are likely to be confused so that people with vision impairments are aware that even sighted people without any form of color blindness can misidentify colors.

It may also be helpful for actual VizWiz users to contribute to a guide on taking photos. The volunteer workers attempted to guide participants with directions such as "move six inches backward from the garment" or "move towards a window" but this information is given after the fact when users may have moved from their original photo spot and the directions may not translate well for a non-sighted person. It may be more helpful for others with vision impairments to give direction from that point-of-view and explain that the photo needed depends on the question asked (that is, a few inches away is good for identifying patterns within a garment but a few feet away is needed to understand if multiple pieces match).

Overall it is desirable to expedite the picture taking process. Though users commented they were able to get faster as they used the system more, one participant commented that she needed to set aside 30 minutes to submit questions and she, along with other participants, often commented that they did not have time to use the system on certain days. Though some users may be motivated enough to use the system regardless of the time it takes, others may become too wary of this amount of effort over time and lose interest in the application.

An additional feature to ensure someone is always online is necessary, such as a list similar to instant messaging systems of who is logged in as well as an "away" status if they temporarily step away. There is also a need for a mobile version of this application so a person can easily answer questions while away from home. Typing responses on a mobile Web browser is difficult due to the small screen size; thus, a PC is the best way to type responses but having the volunteer website in front of you all the time is not feasible and could limit volunteer recruitment in the future.

Our participants expressed that they built trust with the volunteers through the accurate and detailed responses they gave, despite not being "experts". Our volunteer workers were ladies who indicated they were comfortable answering fashion questions but did not have a formal expertise. Though one participant mentioned the desire to have an expert answer questions, all of the participants indicated they were satisfied with the responses including the level of detail and honesty when they were told items did not coordinate. All of our volunteers were from the same culture but most participants said that did not matter.

We observed that our participants built trust with the workers through asking questions they already knew the answer to, or asking their sighted friends or family to validate the worker's feedback. We believe that other systems that employ crowdsourcing alternatives to answering subjective questions should employ similar techniques to build similar trust between participants and workers.

Our initial pilot deployment was only two weeks long and had a small participant pool. We believe this may have affected the number of subjective questions we received as users commented they were more comfortable over time, thus a longer study may have yielded more subjective questions. Also some users experienced technical issues with their devices, which impacted their ability to submit questions during the second week. Aside from the reported technical issues, we cannot fully explain the drop-off in questions in the second week. This further motivates the need for a longitudinal study to ensure this application is beneficial long-term.

Overall we feel that there is ample evidence from our participants that it is possible to crowdsource subjective fashion advice and this solution met a need. One of our participants provided the following reply when we asked if they found the application useful at the end of the study:

> "Yes I did, and certainly would use it for this purpose. It is a much needed level of input, and I wil miss the oppotunity to get this valueable feedback." *[Participant 2]* (Comments copied verbatim)

6. CONCLUSION & FUTURE WORK

Fashion is a visual language that is greatly inaccessible to many people with vision impairments. There are currently no technologies that adequately provide assistance for the subjective nuances of fashion such as coordination and appropriateness. We have conducted a feasibility study to evaluate using the VizWiz application to crowdsource visual and subjective fashion questions from people with vision impairments to sighted volunteers willing to answer. Our pilot study successfully demonstrated that this is a viable solution. Our participants trusted the volunteers even though they did not know them and could not confirm the responses themselves. They generally found the system very useful and one they would like to use on a regular basis. We believe this system could be supported by a core set of volunteers by recruiting from volunteer organizations, sororities and fraternities, stay-at-home parents, and retirees.

This study revealed several research challenges including supporting blind photography and customizing the VizWiz interface for these questions. As future work, we will explore an instruction guide for improving the photo capture. Since the workers sometimes provided differing information, we feel that it would be useful to allow users to select their desired number of responses. We also found that the volunteers talked offline about their responses and would like the ability to talk to each other before responding, or see each other's responses.

Additionally, we will investigate how non-experts might be able to answer questions that require fashion expertise. The 24/7 availability of workers from services such as Amazon's Mechanical Turk allows questions to be answered quickly, but there is no way to guarantee the quality of those answers for subjective questions. We hope to build a tool that would allow non-fashion experts to input the visual knowledge available from users' photographs and then aggregate and interpret that information into usable fashion advice, as a supplement to responses from volunteers.

Based on the success of this pilot study, we will continue to study the interaction between workers and users. From what we have gathered, crowdsourcing subjective fashion information can alleviate a great barrier for the blind community and provide valuable knowledge of this visual medium of fashion.

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