Modality Preference for Rider Reports on Transit Accessibility Problems

Aaron Steinfeld (steinfeld@cmu.edu)
Rafae Dar Aziz (raziz@andrew.cmu.edu)
Lauren Von Dehsen (lvondehs@andrew.cmu.edu)
Sun Young Park (chelsea00ny@gmail.com)

Robotics Institute
Carnegie Mellon University
5000 Forbes Ave
Pittsburgh, Pennsylvania, USA
412-268-6346 (phone)
412-268-6436 (fax)

Jordana L. Maisel (jlmaisel@buffalo.edu)
Edward Steinfeld (arced@buffalo.edu)

IDeA Center
SUNY at Buffalo
378 Hayes Hall, School of Architecture and Planning
3435 Main Street
Buffalo, New York, 14214-3087

(716) 829-3485 x329 (phone)
716-829-3861 (fax)

Corresponding author: Aaron Steinfeld

ABSTRACT

This paper reports on part of a larger effort towards development of a citizen science method to engage riders to document and assess problems and good solutions throughout the system. This model will empower riders, resulting in a greater understanding of the transportation system, and improve the feedback loop between rider and provider. It is important to know what types of multimedia data riders are comfortable and interested in using for reporting their observations. A 2x3 within-participants design was used to explore reporting modality for a full-scale simulated bus shelter scene. The examined factors included the modalities of the Notes (text, audio) and Media (none, photo, video). Data was collected on perceived ease of use, usefulness, social comfort, and overall preference. The results from two user groups, those without disabilities and those who use wheeled mobility devices, suggest that text with photo should be supported and that end users may not view video data as having additional value.

INTRODUCTION

Transit agencies understand and, for the most part, emphasize adherence to the Americans with Disabilities Act and other related accessibility regulations. Since there are products on the market to support most accommodations, the lack of implementation of known best practices is a more serious problem than the lack of technology solutions. Improvements to existing technologies are certainly needed, but, for the short term, the slow adoption rate for best practices and has a more significant impact on people with disabilities. Adoption and maintenance of best practices are hindered by the sheer size and complexity of transit systems and the limited effort agencies can dedicate to accessibility problems given their consistent funding challenges.

Likewise, consumers regularly report little to no feedback when filing problems, often file reports to the wrong government agency, and in some cases it is not clear to the customer service agent where to direct a report within an agency. Positive feedback regarding accessibility improvements faces similar barriers. We suggest that two-way feedback between riders and providers is the key to supporting best practices and propose that technology can be used to streamline this interaction. In particular, we see real promise in the use of citizen science – rich media evidence collected by end users for civic advocacy (Paolos, 2008). We believe citizen science can be an effective and valuable method for enhancing accessibility in transportation settings (Steinfeld, et al 2009). The work described here is a portion of a larger effort towards developing, implementing, and evaluating a software infrastructure for this purpose. The work will culminate in a large-scale field test over a whole metro area.

Accessible public transportation is critically important. It allows individuals with disabilities, especially those with severe disabilities, to have independent access to works sites, educational programs, health facilities, and social and recreational activities. In a mobile culture, full social participation hinges on accessibility of transportation systems. However, the current state of accessible public transportation is a barrier to social participation and, particularly, employment. More than half a million people with disabilities cannot leave their homes because of transportation difficulties (BTS, 2003). Even when they are able to leave their home, one-third of people with disabilities have inadequate access to transportation (NOD, 2004). Consequently, four times as many people with disabilities as people with no disabilities lack suitable transportation options to meet their daily mobility needs (NCD, 2000).

Such difficulty leads to numerous consequences. According to one study, 46% of people with disabilities, compared to 23% of people without disabilities, reported feeling isolated from their communities (NOD, 2000). Individuals with disabilities were five times more likely to report dissatisfaction with their lives than were their non-disabled counterparts, and a majority of those surveyed said that lack of a full social life was a reason for this dissatisfaction. For example, persons with disabilities were about half as likely to have heard live music, gone to a movie, or attended a sporting event or concert over a one-year period (NOD, 2005; Hendershot, 2003). Inadequate transportation limits access to these activities for individuals with disabilities. People with disabilities, both in urban and rural areas, frequently cite a lack of local transportation as hindering their ability to find employment. Lack of transportation (29%) was only second to a lack of appropriate jobs being available (53%), as the most frequently cited reason for being discouraged from looking for work (Loprest & Maag, 2001).

System Wide Assessment

Transit providers and consumer advocates in many locations are working effectively to identify barriers and develop good solutions but these best practices are not being adopted in other locations. For example, the National Organization on Disability published a report entitled "The Current State of Transportation for People with Disabilities" (NCD, 2000). Of the 11 different problems with fixed route systems identified in that report, seven of them were related to service delivery and policies as opposed to vehicle and building technology issues: reliability of stop announcements, maintenance problems with lifts, compliance with lift operation policies, planning accessibility to stations (i.e. accessibility beyond key stations), wheelchair securement policies, elevator maintenance problems, and continued use of poor accessibility solutions like mini-high platforms. Methods are needed to identify problems as they arise, assess the impact of those problems on people with disabilities, and bring this information to the attention of service providers and policy makers as part of operations and planning.

Surveys are a common method to assess a metropolitan area but they have limitations. For example, survey methods make it difficult for respondents to define the issues from their own perspective (Zeisel, 1984), data collection is time consuming and protracted, and there are numerous barriers to independent analysis and advocacy by end users. Options like guided tours, in which end users identify problems and solutions to researchers in naturalistic settings, are extremely valuable because the exposure to real settings and products is very effective in prompting detailed responses from the end user (Hershberger, 2002; Groat, 2002). Interviews and focus groups allow individuals to define issues from their own perspective (Ayoob, et al 2003). However, due to high cost and logistics these methods are often constrained by small sample size problems and are difficult to maintain on a continuous basis. They are more suitable for periodic assessments, as a prelude to other research, and to elicit end user input. Based on interviews conducted by the team, there also appears to be a general belief among riders that complaints made through transit agency phone numbers and web forms have limited value and that feedback is rare.

Enabling The End User To Make A Difference With Technology

A key limitation of many approaches is that the process of data collection is slow, does not empower end users or support their immediate needs, and often does not offer service providers evidence in a form that is directly applicable to their needs. For example, a survey of riders with disabilities or focus groups may identify that lift breakdowns are a frequent problem but not whether some lift models and bus routes are more prone to problems than others. In fact, by the time data is obtained, the problem may already be fixed.

The widespread availability of personal electronics provides an opportunity to implement this scenario using the end users' very own cameras and mobile phones (Figure 1). These ubiquitous consumer products are often capable of multimedia recording. Thus, they provide an opportunity for end users to collect data that can be used as a research database. A good participatory action design (Ding, et al 2007) approach is to go further and enable real time access to the data, thereby enabling continuous interaction between researchers and end users.

There are many examples that demonstrate the value of using this form of data collection. For example, Paulos points to citizen science work in air quality and public parks (Paulos, 2008). Similar efforts have occurred in documenting accessibility barriers at a citywide scale (Figure 2). Multimedia is much more powerful than dry statistical data and these methods provide concrete evidence of problems.



Figure 1. An example image of a maintenance problem

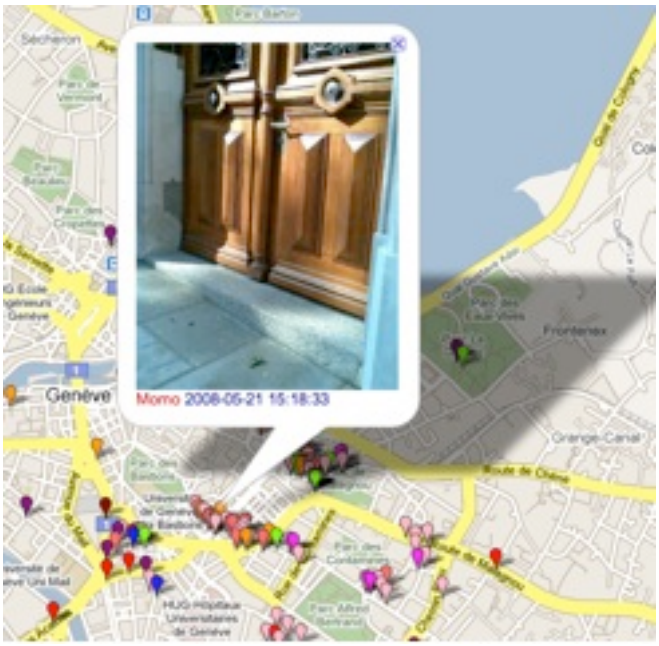


Figure 2. Community reporting of accessibility barriers in Geneva (http://www.zexe.net/GENEVE/map.php)

ParkScan.org in San Francisco is one of the best models currently in use. The city park domain is a good metaphor for citizen science in public transportation given the similar issues with physical and organizational complexity. In 2007 alone, ParkScan had 425 registered users, 1,531 observations, and 68% of the issues identified by end users were addressed by the City (NPC, 2008). What sets ParkScan.org apart from other citizen science communities is that there is a feedback loop between the City and the users. This is most directly manifested by allowing City workers to reply back within a contributed report (e.g., Figure 3). Park employees have access to the observations through an internal interface designed to support their needs.

The ParkScan.org model is interesting in that the communication channel is between the rider and worker. This relieves pressure on customer service agents and the semi-anonomous, asynchronous nature allows the bare minimum of text entry by the worker assigned to the observation. The ability of users to track observation also mitigates the "black hole" effect a user may experience if no follow-up is enabled.

When describing the citizen science model to transit agencies there is a definite awareness that the first wave of observations has

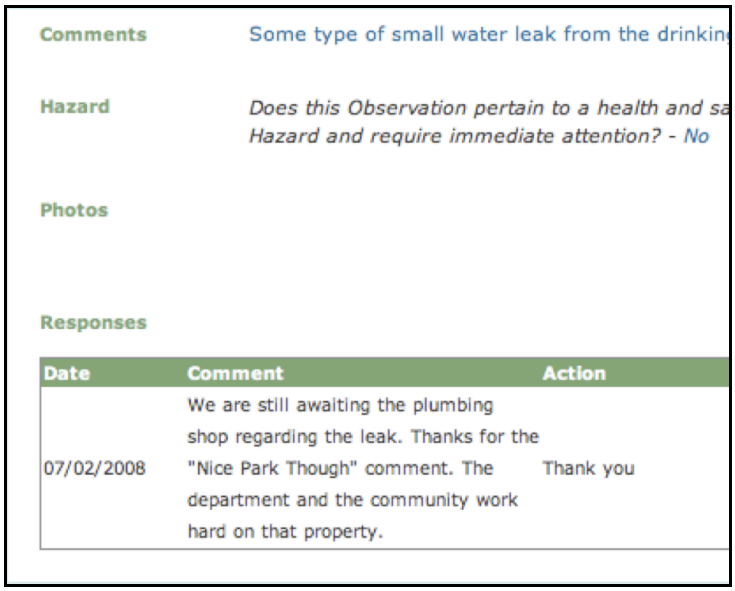


Figure 3. Example record from ParkScan.org

the potential to be rather large due to the sudden reporting of previously unknown problems. However, there was deep appreciation for the potential to foster greater collaboration between riders and providers over the long term. This can lead to fostering greater community advocacy on behalf of the agency (e.g., funding sources). Furthermore, the record of observations permits better prioritization and planning of maintence activities and rationale for major investments.

Media Options for Reporting

Rich multimedia provides extremely persuasive evidence for end users to promote change in their communities and in policies at a national level. The ParkScan.org implementation has the option to contribute images with the text report, somewhat like the MMS submission process used in the accessibility reporting websites (e.g., Figure 2) and some citizen science sites include the option to upload video.

Multimedia documentation is sometimes done for related activities but not used for improving system accessibility. For example, interviews with one power wheelchair user revealed that she documented the path from a mainline stop to a common destination in order to prove that it was not accessible. Without such proof, she was required to pay out of pocket for the full $20 paratransit fare.

There are, however, potential reasons for not collecting multimedia. These include the hassle of carrying and using a photo or video capable device, the potential to feel less secure due to risk of theft, and uneasiness on the part of security professionals regarding the use of such devices in transit stations and terminals.

This, combined with the existing options of phone and web based problem reporting, leads to some core research questions:

- Which reporting options do end users prefer?
- How do factors like added hassle and perceived social comfort vary by reporting method?
- Based on end user perceptions, what reporting methods should citizen science websites support?

EXPERIMENT METHOD

Participants

During recruitment, the participants were informed they would be completing surveys and documenting items in the laboratory. All participants were paid volunteers and fully consented. There were two participant groups: wheeled mobility device users (WMD) and people without disabilities (Control). Each group had 12 participants. While the latter group may seem unnecessary, we believe that the best way to deploy a citizen science system is to appeal to the full spectrum of potential end users. This universal design approach means that riders without disabilities can use the same system to report problems that matter to them (e.g., vandalism, broken glass, etc). As with ParkScan.org, the system would be a key tool for providing general customer service and developing a collaborative relationship with all users.

Participants were recruited from local universities and the general public using a local recruitment website, contacts in local organizations, and community email lists. Participants were required to be 18 years of age or older, fluent in English, and not affiliated with the project. The inclusion criteria for the WMD group were anyone who met the general requirements and used either a wheelchair or scooter.

Design & Materials

The study was a 2x3 design. The first effect was the modality corresponding to the Notes about the problem. These were either in Audio or Text form and corresponded to either a voicemail or email/web documentation of the problem. Audio reports were recorded on a digital voice recorder while text reports were typed into a text editor on a computer. Since it was not possible to have a full array of accessible computer modification devices, participants who could not type narrated to an experimenter who typed their entry verbatim under the participant's supervision. Editing of text was allowed.

The second effect was the Media used to support the notes. These were None, Photo, and Video. The middle was documented using a consumer grade 10-megapixel Canon digital camera while the latter used a 720p Flip digital video recorder. WMD participants who could not hold the camera or video recorder in a stable manner were given the option of using a flexible stalk mount (The Smart Pod) which was attached to their wheeled device using a clamp.

The permutations of the 2x3 design led to six conditions. To prevent bias, each condition was tested with one of six different paired information and spatial problem stimuli. Half of each participant group used a different Set of stimuli. Set "A" consisted of surface conditions related to bus shelter upkeep (e.g., accumulated snow, accumulated ice, trash, dirt pile, broken glass, etc) and bus information conditions related to the bus stop sign (e.g., no labels, vandalized, worn out labels, labels on wrong side of sign, etc). Set "B" consisted of spatial conditions related to movement in and around the shelter (e.g., full bench, narrow passage, permanent blockages, narrow sidewalk, etc) and bus information conditions related to the bus schedule sign inside the shelter (e.g., water damage, graffiti, broken glass, stickers, etc).

All conditions and stimuli were run within-participants in a counterbalanced order. Counterbalancing also included the order in which participants reported on information and spatial stimuli. The combined pattern is shown in Table 1 (e.g., "T N : S, I 1" corresponds to "Text+None, Spatial first, Information second, paired set #1").The design was constructed by nesting 2-level and 3-level Latin Squares. The table was replicated for each participant group.

Table 1. Counterbalance order (replicated for each group)

Participant	Trial Order					
	1	2	3	4	5	6
Stimulus Set A						
1	T N : S, I 1	A N : S, I 2	T P: S, I 6	A P: I, S 3	T V: I, S 5	A V: I, S 4
2	T P: I, S 2	A P: I, S 3	T V: I, S 1	A V: S, I 4	T N : S, I 6	A N : S, I 5
3	T V: S, I 3	A V: S, I 4	T N : S, I 2	A N : I, S 5	T P: I, S 1	A P: I, S 6
4	A N : I, S 4	T N : I, S 5	A P: I, S 3	T P: S, I 6	A V: S, I 2	T V: S, I 1
5	A P: S, I 5	T P: S, I 6	A V: S, I 4	T V: I, S 1	A N : I, S 3	T N : I, S 2
6	A V: I, S 6	T V: I, S 1	A N : I, S 5	T N : S, I 2	A P: S, I 4	T P: S, I 3
Stimulus Set B						
7	T N : S, I 1	A N : S, I 2	T P: S, I 6	A P: I, S 3	T V: I, S 5	A V: I, S 4
8	T P: I, S 2	A P: I, S 3	T V: I, S 1	A V: S, I 4	T N : S, I 6	A N : S, I 5
9	T V: S, I 3	A V: S, I 4	T N : S, I 2	A N : I, S 5	T P: I, S 1	A P: I, S 6
10	A N : I, S 4	T N : I, S 5	A P: I, S 3	T P: S, I 6	A V: S, I 2	T V: S, I 1
11	A P: S, I 5	T P: S, I 6	A V: S, I 4	T V: I, S 1	A N : I, S 3	T N : I, S 2
12	A V: I, S 6	T V: I, S 1	A N : I, S 5	T N : S, I 2	A P: S, I 4	T P: S, I 3

Effects: notes (Text, Audio)
media (None, Photo, Video)

Stimuli: Space
Informational

#: Stimulus pair #

Storyline & Procedure

A simulated bus shelter was created inside the laboratory for this experiment (Figure 4). This included an advertising poster, a bench, a tempered glass panel on the upstream side of the shelter, a place to mount route information signs (inside, above end of bench), and a bus stop sign with interchangeable route label panels.



Figure 4. Experimental apparatus with simulated snow and wide "sidewalk"

Control participants were told that they were approaching the bus shelter to take a bus with a friend who uses a wheelchair or scooter. WMD participants were told they were approaching the bus shelter to take a bus. Both groups were told this was an unfamiliar stop. In Set A, the WMD user intended to park under the bus shelter and needed to confirm that this was the correct bus stop for their desired bus. In Set B, the WMD user wanted to maneuver around the shelter to board the bus and needed to see if they had missed the bus based on the schedule. All participants were asked to stay on the "sidewalk" which was delineated from the street by a cardboard curb.

For each condition the participant was asked to report the problem to the transit authority using the Notes and Media provided. For both Note methods, participants were asked to describe the problem so that a transit authority would be able identify and fix the problem. When using the camera, participants were asked to take one picture that "best" documented the problem that would accompany their Note. For the video recorder, participants were asked to film a clip of 15 seconds or less that would accompany their Note.

Participants were present for varying durations, depending on the speed in which they completed the documentation. A pre-experiment survey covering demographics, disability, and technology attitudes and a post-test survey covering experience were given to each participant. The former was a subset of questions developed by the Quality of Life Technologies Engineering Research Center (Beach, et al 2008). These were selected in order to provide the option to draw inferences to the hundreds of samples collected by the survey developers and related transportation studies (e.g., Beyene, et al 2009). The latter included questions on transit complaint filing, technology use, media sharing website use, and 7-point scale ratings for (a) experiment condition preference and (b) regarding the merit of each condition for documenting broken lifts/ramps on vehicles and problems with not getting on a bus due to overcrowding. These two problems were examined with the post-test survey since they would be difficult to recreate using a full-scale simulation.

Within the study, each participant completed an identical post-condition survey (Table 2) after each condition. Part of this survey was based on a previously validated survey for desktop

computing (Steinfeld, et al 2007) but new questions were added to collect additional data on perceived usefulness and on perceived social discomfort. The latter were developed during review of other studies on perceived vulnerability (e.g., Killias & Clerici, 2000; Bifulco, et al 2003). Participants were not shown the index labels.

RESULTS

Analysis Methodology & Bias Checks

As implied by the core research questions mentioned in the Introduction, this paper is focused on the post-condition and post-test survey results. Analysis of the actual data collected by the participants is deferred to future publications. Unless otherwise noted, comparisons were analyzed using ANOVA with Notes and Media as main effects, followed by a Tukey HSD post-hoc where appropriate.

For the purposes of analysis, responses to each question within each post-condition survey category (Ease of Use, Usefulness, and Social Comfort) were flipped to have the same positive/negative direction, with higher as better, and averaged as a group. The three resulting Index groups all surpassed the 0.7 reliability acceptance threshold used in the literature (Table 2). ANOVA analyses were run on to determine if there were Ordering effects or differences in the two stimuli Sets. There were no significant results except a small difference in ease of use for stimuli Set (F=6.0, p=0.016). Set A had higher ratings than set B (6.2 vs. 5.8). A subsequent check for interactions between Set and the conditions (Notes, Media) revealed no significant difference so there is little risk of bias due to this difference.

Table 2. Post-condition survey (7-point scale from strongly disagree to strongly agree)

Ease of Use	*Cronbach's alpha:* 0.82
1. Learning to use this method was easy	
2. Becoming skillful with this method was easy	
3. I had no problem physically using this method	
Usefulness, part 1	*(both parts)* 0.79
4. Using this method would improve my performance in reporting observations	
5. Using this method for reporting observations would increase my productivity	
6. I feel this method is too slow for everyday use *(r)*	
Social Comfort	0.87
7. I felt uncomfortable using this method when people were around in public *(r)*	
8. When I use this method, I feel like other people are looking at me *(r)*	
9. Using this method in front of strangers embarrasses me *(r)*	
Usefulness, part 2	
10. I like the idea of using this method	
11. I would have done as good a job without using this method *(r)*	
12. Carrying items to do this method on daily trip is such a hassle to me *(r)*	

(r) = scale reversed for index averages and analysis

There was also concern that comfort with uploading photos or videos to websites would incur an unmanageable negative bias on the data. The post-test survey included a question to this effect, "Have you uploaded photos or videos before? If yes, are you comfortable doing upload photos or videos?" One Control participant and three WMD participants responded they had not uploaded photos or videos. All other participants indicated comfort with the process except for one WMD participant. While only two thirds of the WMD participants reported comfort with such activity, the quantity seems within reason.

Findings

The effects of Notes and Media were analyzed in a full factorial ANOVA along with Group (Control, WMD) on Ease of Use. While Audio reports had a slightly higher mean than Text notes for WMD participants (6.1 vs. 5.8), the Control participants had the inverse

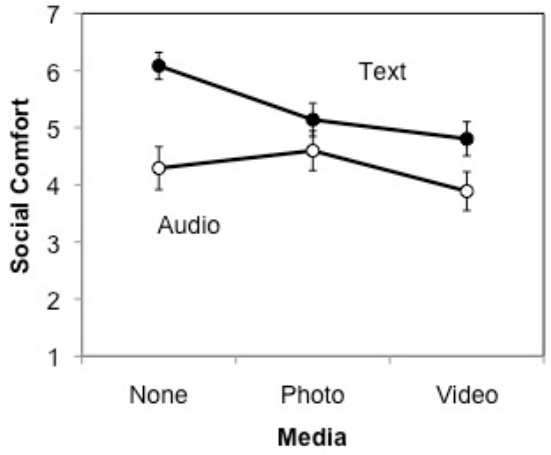


Figure 5. Media results for Social Comfort (±1 std error)

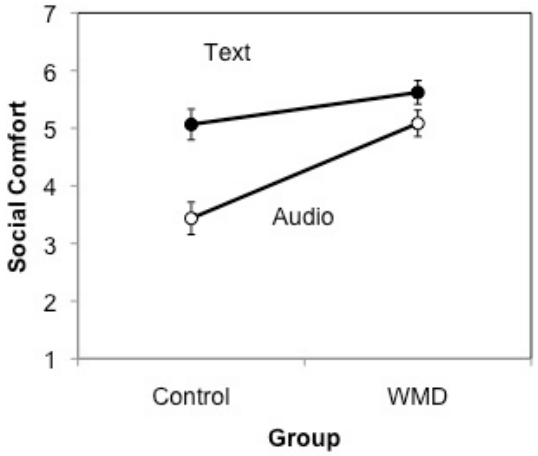


Figure 6. Group results for Social Comfort (±1 std error)

relationship (5.7 vs. 6.4). This resulted in a significant interaction between Group and Notes for Ease of Use ($F=5.9$, $p=0.017$). However, the Tukey HSD post-hoc revealed no differences among the four combinations. There were no other significant differences for Ease of Use.

Social Comfort ($F=20.4$, $p<0.0001$) was higher for Text notes when compared to Audio notes (Figure 5). There was also a significant difference in Social Comfort for Media type ($F=4.2$, $p=0.018$) with post-hoc results showing significant differences between None and Video. There were also differences in Group ($F=21.1$, $p<0.0001$) and the interaction between Notes and Group ($F=5.2$, $p=0.02$). The post-hoc revealed that the Control group reported significantly reduced Social Comfort for Audio as compared to the other three combinations.

Usefulness mimicked some of the trends seen in other metrics but did not result in significant differences at the $p<0.05$ level. Note type was not significant. There was a slight significant difference for Media on question 12 (hassle) with Video showing a full point higher hassle than None in the post-hoc ($F=24.1$, $p=0.047$).

Figure 7 shows the post-test preference ratings across all participants. There was a significant difference in Notes ($F=26.7$, $p=0.004$) and Media ($F=24.5$, $p=0.023$) but no Group or interaction effects. Post-hoc analysis showed Photo was significantly higher than Video.

Ratings for documenting problems with broken lifts/ramps and getting on a bus due to overcrowding were generally high for the photo and video media types (Figure 8). While there was a visible trend for broken lifts/ramps for Media, only Group showed a significant difference with WMD participants providing lower ratings than Control participants (4.8 vs. 5.8, $F=10.8$, $p=0.001$). For overcrowding, there was a significant Media effect ($F=5.7$, $p=0.004$) with None being significantly lower than the other two options. There was also a significant difference for Group ($F=4.9$, $p=0.029$) with lower ratings from WMD participants (4.7 vs. 5.3). The lower responses from the WMD group is not surprising in that these events are fast paced, thus making it hard for WMD participants with limited dexterity to capture photo or video evidence. In fact, a subsequent t-test comparing Control and WMD responses to these two questions on only the None conditions revealed no significant differences.

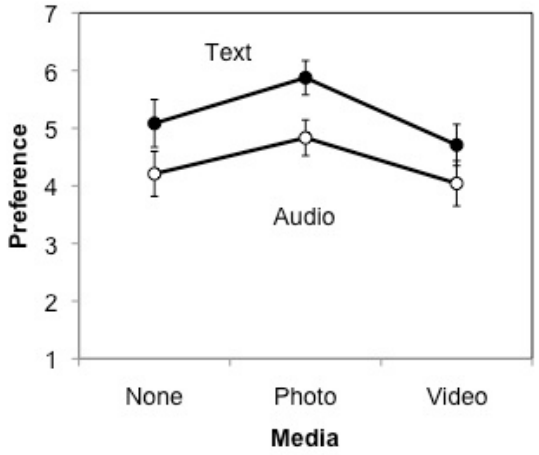


Figure 7. Preference ratings (±1 std error)

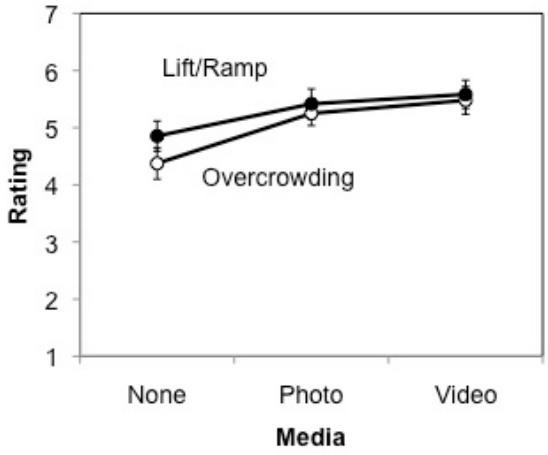


Figure 8. Use when documenting problems (1-7, very bad to very good, ±1 std error)

There was additional supporting data for the photo modality. The post-test survey included the Yes/No question: "When explaining an experience, I usually prefer to include visual information, instead of just text." Over 70% of the participants responded positively. Also, the survey ended with a free form section where participants could provide comments and suggestions. Some of the remarks aligned with the other results:

- "… For some reason I felt it was more on the spot with audio."
- "I liked the camera and text approach the best. But I hate text messaging on the cell phone because my vision is not the best and texting is laborious. For me I would like to take a picture then go back to my office or home and write the complaint out. This gives me time to calm down after I have been upset by some incident."

Two participants, including one WMD user, voluntarily commented on the fidelity of the scenario simulations:

- "Great props!"
- "The scenarios were really well represented as situations that I have actually come across which is why I no longer ride the bus."

DISCUSSION

Which reporting options do end users prefer?

Riders clearly had a high preference for the text and photo combination. Conditions with audio were less preferred than their text counterparts. It is important to note that nobody in the study was blind or had low vision. Such groups may express higher preferences for audio options. Future research with this population is in the project plan.

How do factors like added hassle and perceived social comfort vary by reporting method?

Conditions with text were viewed as having considerably higher social comfort than audio conditions. Likewise, video scored slightly worse than the other media options and was reported to be more of a hassle than the no media approach. These findings align with the high

incidence of text messaging in public and the social implications of video recording around strangers. There may also be a perceived risk to using an apparently more expensive device – even though the camera and video recorder used in this study were of comparable value and far cheaper than some smart phones.

There were no apparent differences in perceived hassle or social comfort when comparing no media to photo, thus implying that documenting a problem with some types of rich multimedia is similar to traditional methods for such metrics.

Based on end user perceptions, what reporting methods should citizen science websites support?

The consistent, favorable results for the text with photo condition suggest this combination has merit. This is supported by the large quantities of MMS-based reports collected during citizen science accessibility efforts in Geneva and elsewhere. The mixed results for the video options suggest that the lukewarm perceived value of video might not justify the added data storage, bandwidth, and user interface requirements. While detailed analysis of the data collected by participants is not ready, our anecdotal observations are that the video data tends to include a lot of useless and noisy start-up and shutdown footage while the user manipulates the recorder. Some consumer devices now support easy video clip extraction, but it is unclear as to whether such features will actually be frequently used by users.

While the poor results for the audio conditions also suggests low value, we do not expect such results from riders who are blind, have low vision, or poor manual dexterity. Data from future studies may confirm this prediction.

Therefore, the combination of subjective data collected in this study and universal design principles suggests that citizen science websites should support both text and audio documentation and favor end user contributed photographs. Future analysis will examine the relative quality of the documentation collected under the six conditions and provide input on the ability of end users to collect useful multimedia data.

As mentioned, the work described here is a portion of a larger effort towards developing, implementing, and evaluating a software infrastructure for this purpose. Additional experiments on related issues and with other populations are planned. The project will culminate in a large-scale field test over a whole metro area.

ACKNOWLEDGMENTS

The authors would like to thank colleagues in the local Pittsburgh area who facilitated participant recruitment.

The Rehabilitation Engineering Research Center on Accessible Public Transportation (RERC-APT) is funded by grant number H133E080019 from the United States Department of Education through the National Institute on Disability and Rehabilitation Research.

REFERENCES

Ayoob, E., Steinfeld, A. & Grace, R. (2003). Identification of an appropriate drowsy driver detection interface for commercial vehicle operations, in *Proc. Human Factors and Ergonomics Society 47th Annual Meeting*.

Beach, S.R., Schulz, R., De Bruine Bruin, W., Downs, J., Musa, D., & Matthews, J. (2008, November). Privacy attitudes and quality of life technology in disabled and non-disabled baby boomers and older adults. Presented at the *Annual Scientific Meeting of the Gerontological Society of America*, National Harbor, MD.

Beyene, N., Cooper, R., & Steinfeld, A. (2009). Driving status and the inner drive for community mobility and participation: A survey of people with disabilities and senior citizens from support groups in New Delhi, India. Proceedings of the Rehabilitation Engineering & Assistive Technology Society of North America (RESNA) Conference.

Bifulco, A., Mahon, J., Kwon, H. P., Moran, P. M., Jacobs, C. (2003). The Vulnerable Attachment Style Questionnaire (VASQ): an interview-based measure of attachment styles that predict depressive disorder. *Psychological Medicine*, 33, 1099–1110.

Bureau of Transportation Statistics (2003, April). *Transportation difficulties keep over half a million disabled at home, BTS Issue Brief, No. 3*. U.S. Department of Transportation.

Ding, D., Cooper, R. A., & Pearlman, J. (2007). Incorporating participatory action design into research and education, *International Conference on Electrical Engineering*.

Hendershot, G. (2003). *Community participation and life satisfaction*, www.nod.org/index.cfm?fuseaction=Feature.showFeature&FeatureID=1129 (Acc. March 12, 2008).

Hershberger, R. (2002). Behavior-based architectural programming, in *Handbook of environmental psychology*, R. Bechtel and A. Churchman, Eds. New York: John Wiley & Sons, Inc, pp. 292-305.

Groat, L. (2002). Qualitative research, in *Architectural research methods*, L. Groat and D. Wang, Eds. New York: John Wiley & Sons, Inc, pp. 173-202.

Killias, M., Clerici, C. (2000). Different measures of vulnerability in their relation to different dimensions of fear of crime. *British Journal of Criminology*, 40, 437-450.

Loprest, P. & Maag, E. (2001). *Barriers to and supports for work among adults with disabilities: Results from the NHIS-D*. Washington, DC: The Urban Institute.

National Council on Disability (2000). *The current state of transportation for people with disabilities in the United States*. Washington, DC: National Council on Disability, 2005.

National Organization on Disability (2000). N.O.D./Harris Survey of Community Participation. http://www.nod.org/content.cfm?id=798. (Acc. March 4, 2008).

National Organization on Disability (2004). *N.O.D./Harris Survey of Americans with Disabilities*. www.nod.org/index.cfm?fuseaction=Feature.showFeature&FeatureID=1422 (Acc. March 4, 2008).

Neighborhood Park's Council (2008). *2007 ParkScan.org annual report*, www.parkscan.org/pdf/2007/ParkScan_Report_2007_web.pdf (Acc. March 20, 2008).

Paulos, E. (2008). Citizen science: Enabling participatory urbanism, in *Urban informatics: Community integration and implementation, information science reference*, M. Foth, Ed. IGI Global.

Steinfeld, A., Maisel, J. L., & Steinfeld, E. (2009). The value of citizen science to promote transit accessibility. *First International Symposium on Quality of Life Technology*.

Steinfeld, A., Quinones, P.-A., Zimmerman, J., Bennett, S. R., & Siewiorek, D. (2007). Survey measures for evaluation of cognitive assistants, *NIST Performance Metrics for Intelligent Systems Workshop (PerMIS)*.

Zeisel, J. (1984). *Inquiry by design: Tools for environment-behaviour research (environment and behavior)*. London: Cambridge University Press.