Adoption of Electronic Technology of Recreational Road Cyclists in the Mid-Atlantic Region

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Abstract

Ubiquitous computing is growing in popularity and in impact. This pilot study looks at the adoption and iterative updating of one of the earliest forms of ubiquitous computing, the bicycle computer. It appears to expose a new kind of user dynamic, that of *Experience Augmenting Ubiquitous Computing*. A perspective that seems to best describe this dynamic is Norman's elements of attraction in Emotional Design[1]. In this perspective, the *Visceral* element is dominated by the experience, rather than the design. The Ubiquitous Device then contributes to the *Behavioral* and *Reflective* elements of the experience.

Study motivation and research questions

The study started out as an examination of the technology adoption models with respect to bicycle computer adoption among experienced cyclists, who's involvement in riding spanned the introduction and evolution of the bicycle computer.

The assumption was that the results of the study would fit neatly into the prior research into technology adoption. Studies have led to numerous technology adoption models, or TAMs. Early work at Stanford by Schmittleman and Mahajan[2] and was extended over time, becoming Venkatesh's UTAUT[3], and beyond. The model has been repeatedly validated as well[456].

Nonetheless, ubiquitous computing systems as embodied in bicycle computers are different from the technologies typically described in technology adoption, in that the *decision to adopt* bicycle computer technology is rarely made. Typically, a bike computer is sold with the bicycle as part of the entire package, where the bicycle itself is the point of concern. Bike computers are now so inexpensive, (as little as $6.00 in an Amazon.com search for "Bike Computer" in the Sports and Outdoors department on Dec15, 2012), that any "road" bicycle is sold with one unless the customer actively resists.

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[1] Design, Emotional. "Why we love (or hate) everyday things." *New York: Basic*(2004).

[2] Schmittlein, David C., and Vijay Mahajan. "Maximum likelihood estimation for an innovation diffusion model of new product acceptance." *Marketing science*1.1 (1982): 57-78.

[3] Venkatesh, Viswanath, et al. "User acceptance of information technology: Toward a unified view." *MIS quarterly* (2003): 425-478.

[4] King, William R., and Jun He. "A meta-analysis of the technology acceptance model." *Information & Management* 43.6 (2006): 740-755

[5] Schepers, Jeroen, and Martin Wetzels. "A meta-analysis of the technology acceptance model: Investigating subjective norm and moderation effects."*Information & Management* 44.1 (2007): 90-103.

[6] Ma, Qingxiong, and Liping Liu. "The technology acceptance model: a meta-analysis of empirical findings." *Journal of Organizational and End User Computing (JOEUC)* 16.1 (2004): 59-72.

This means that the "adoption" part of the process occurs before the customer can actually be involved in a decision-making process. As such, the first time a user is actually involved in the decision of which computer to buy, there is a considerable background of experience with the initial bike computer.

So although working within the TAM/UTAUT context certainly could have been done, as the study evolved, it became clear that there were other ways to describe this process in a way that might be more simple and straightforward. There is some support for alternate approaches, as some now believe that the multiple TAMs and UTAUTs have become so generalized that they are too applicable, and as such, are less useful than they could be[7].

Norman, with his work on emotional design[1], describes three types of attraction - Visceral, Behavioral, and Reflective. This appeared to fit the concepts that were emerging in the data, so the analysis is performed from this perspective.

Study design & rationale

This particular study was chosen to take advantage of the researcher's (my) background. I am an experienced "road bicyclist" in the Mid Atlantic region. I log between 5,000 and 11,000 miles per year, and have involved socially in the "cycling lifestyle" since 1989. I have engaged in charity rides, bicycle clubs and trips, and had a modest history of racing. I am acquainted with over one hundred cyclists with various levels of skill and expertise. The community I am primarily involved in is "road cycling". There are many other groups in the culture, including but not limited to "mountain biking", "BMX", and "city". My background has some overlap with the "ultraendurance", "road racing" and "cyclocross" communities.

The "bounded system"[8] in this case study is the interaction of users with their bicycle computers. Like the subjects in the interviews, I have had more computers than I can count, and I remember the initial introduction of the technology. Over the years, I have owned a wide variety of computers, ranging from simple units that simply gave distance and average speed, to much more complex and expensive units that display power, heart rate, GPS position, airspeed, slope, etc. I have noticed in myself, that the type, presence or absence of a bike computer influences the type of experience I have while riding. For example, when struggling into the wind, I will often switch my iBike[9] from ground speed to air speed. Looking down at the speedometer and seeing my speed jump from say, under 15mph to over 30mph turns what was a grind into a headwind to a satisfying effort. It has always been interesting to me how this use of this small piece of technology has the ability to change the subjective experience of riding.

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[7] Straub, D. W., and Andrew Burton-Jones. "Veni, vidi, vici: Breaking the TAM logjam." *Journal of the Association for Information Systems* 8.4 (2007): 223-229.

[8] Merriam, Sharan B. *Qualitative research: A guide to design and implementation*. Jossey-Bass, 2009. pp 81

[9] http://ibikesports.com/NEWTON.html: December 16, 2012.

One question of the study is *Does this technology affect other riders similarly*? Intertwined with this question is the ubiquity of bicycle computers. Throughout the history of most riders, many bike computers will have been bout and used. This means that riders have the ability to interactively adjust their cycling experience as they have to replace their computers. So the other primary question of the study is *Does this affect the type of computer bought by road riders? If so, what are the patterns*?

As a deeply involved member of the Mid Atlantic road riding community, I was able to purposively access a typical sample[10] within my social network. All subjects interviewed were extremely experienced cyclists. All have ridden for more than 10 years, with yearly cumulative totals in excess of 5,000 miles. Subjects have all owned more bike computers than they can recall, and many of them have riding careers that pre-date the existence of electronic bicycle computers. As this was a pilot study with significant time constrains, the sample size was kept small. Out of a population ten requests for an interview, five responded in time to be incorporated into this study.

Merriam suggests that semi-structured interviews are useful when "specific information is desired from all respondents"[11]. In this case, the specific information had to do with the interactions that the subjects of the study had with their bicycle computers over their history, so the structure of the interview was loose.

The "loose structure" was chosen so that concepts could emerge, rather than the perspective of the interviewer dictating too many aspects of the discussion. The main constraint was to focus the subject on discussing their experiences and thoughts with respect to bicycle computers. Areas that seemed to be glossed over were probed to add detail. An effort was made to ask the subjects to clarify what they said, rather than bringing up new material.

To prompt discussion, subjects were asked to gather up any of their old bike computers they could find and place them nearby so that they could be referenced. After a few general questions about cycling in general to make the subjects comfortable with the interview process, the subjects were asked to discuss their history with bike computers. At this point, interviews diverged as each subject discussed their own unique experience with bike computers.

All interviews had both audio and video recorded. Video was recorded using a Canon EOS recording 648x480 resolution MPEG to a 32GB SIMM card. Audio was recorded using a lavalier microphone attached to the subject and wired to the camera. interviews were conducted at the subjects homes, using available light. The interviewer sat at a distance from the camera so as not to bring undue attention to the recording equipment.

Interviews were then transcribed using Dragon 12, and then cleaned up manually. Interestingly, after training Dragon with 5 minutes of each interview, accuracy ranged

[10] Merriam, Sharan B. *Qualitative research: A guide to design and implementation*. Jossey-Bass, 2009. pp 78
[11] Merriam, Sharan B. *Qualitative research: A guide to design and implementation*. Jossey-Bass, 2009. pp 90

from 50% to 90% per paragraph with respect to text. Punctuation had to be added manually in nearly every case.

Once transcribed, interviews were placed into an Excel spreadsheet with each row containing the name of the subject, a quote (roughly paragraph in length), category, tense, and comments. Transcriptions were filtered for discussion that pertained to bicycle computers. For example, discussion of bike trips that did not involve references to training with or using a computer during the trip were discarded. An example of such an exclusion would be:

> *All right, I got seriously in the cycling when I was in the air force in 1973 to '75 because I was on a base in which it was very easy to ride a bicycle to work. I started out doing that and when I finished, by the time I finished two years I decided get rid of the junker that I'd been riding got a got a really nice bike. From a local bike store.*

Coding was accomplished by analyzing each quote for which aspect of Norman's emotional dimensions was being expressed.

Norman lays out his "Three Levels of Processing, Visceral, Behavioral, and Reflective"[12] as follows:

- *The visceral level is pre-conscious, pre thought. This is where appearance matters and first impressions are formed. Visceral design is about the impact of a product, about it's experience, tough and feel.*
- *The behavioral level is about use, about experience with a product ... function, performance and usability.*
- *Interpretation, understanding and reasoning come from the reflective level.*

Quotes were examined for words or concepts that reflect Norman's levels. Paragraphs that discuss the look, feel, or similar aspects were coded as visceral. Paragraphs that discussed the usability, function(s), and performance of a device were coded as behavioral. Quotes were coded as reflective if they discussed higher-level integration of experience with computers, such as accumulating and analyzing data.

An example of a quote coded as visceral comes from subject S:

> *I was at Performance Bike and I wanted a wireless, for aesthetic reasons.*

An example of a quote coded as behavioral comes from subject B:

> *And it had smaller numbers and three buttons it was a little harder to make out if you're bouncing down the road*

Lastly, an example of a quote coded as reflective comes from subject G:

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[12] Design, Emotional. "Why we love (or hate) everyday things." *New York: Basic*(2004). pp 21- 38

> *I started in 1988 to actually log mileage, and then for some actually wrote everything down and I've written down every workout since 1988.*

Coding of tense was accomplished simply by determining if the subject was referring to the past, present or future in the selected quote.

Initial analysis

Analysis was simple (probably excessively so), due to the time constraints involved. The spreadsheet was uploaded to a data analysis and visualization program that I wrote, The VISIBILITY Data Suite[13][14], where rough quantitative analysis that required frequency analysis was performed. Once frequencies were determined, additional analysis on that data was performed in Excel.

Of the total 27,135 words transcribed in the interviews, 10,815 were coded for this analysis. These were grouped into 191 paragraphs that referenced, as much as possible, a single processing level. A graph of the contributions by paragraph for each subject are shown in figure 1.

As mentioned above, there were five subjects interviewed, hereafter referred to as B, G, M, S and E. All interviewees log an estimated average of between 5,000 and 10,000 miles per year. A brief description of each subject follows:

B is in his early 50s. He has been riding for approximately 20 years, and has a significant racing background, though he is currently only a recreational rider. He currently uses a low-cost, simple bike computer that shows the basic functions - speed, average speed, trip distance and total distance. He owns a smartphone which does have some apps that pertain to tracking fitness, though these are mostly used for running. A total of 33 quotes were coded from the interview.

G is in his mid 60s. His riding career spans nearly 40 years. As with B, he has a significant racing background, and now engages in "ultraendurance" riding, or randoneuring. He has competed in this category for the last several years and has completed one of the hardest events of this type, *Paris-Brest-Paris* twice. He currently uses a low-cost, simple bike computer that shows the basic functions - speed, average speed, trip distance and total distance. He owns a smartphone which he integrates into his riding. A total of 43 quotes were coded from the interview.

M is in his late 50s. He has been riding and or running for approximately the past 30 years. He has competed in triathlons, though is now only a recreational rider. He currently uses a Garmin Edge 800[15]. He owns a smartphone, but does not use it for his activities. A total of 23 quotes were coded from the interview.

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[13] http://www.fgmdev.com/viewarticle.php?article_number=4 (December 17th 2012)
[14] http://www.fgmdev.com/viewarticle.php?article_number=5 (December 17th 2012)
[15] https://buy.garmin.com/shop/shop.do?cID=160&pID=69043 (December 17th 2012)

S is in his early 60s. He has been riding for the last 10 years a recreational cyclist, and spent several years before that intermittently riding as a commuter. He has never raced. He currently uses a Garmin 500[16] and an iBike Newton[17]. He does not own a smartphone. A total of 41 quotes were coded from the interview.

E is in his late 60s. He has been riding for over 40 years as a recreational cyclist. He has commuted some and continues to do so sporadically. He has never raced. He currently uses a Gamin Edge 800[18]. He owns a smartphone, and has occasionally used it to record a ride when he was unable to use his other devices. A total of 51 quotes were coded from the interview.

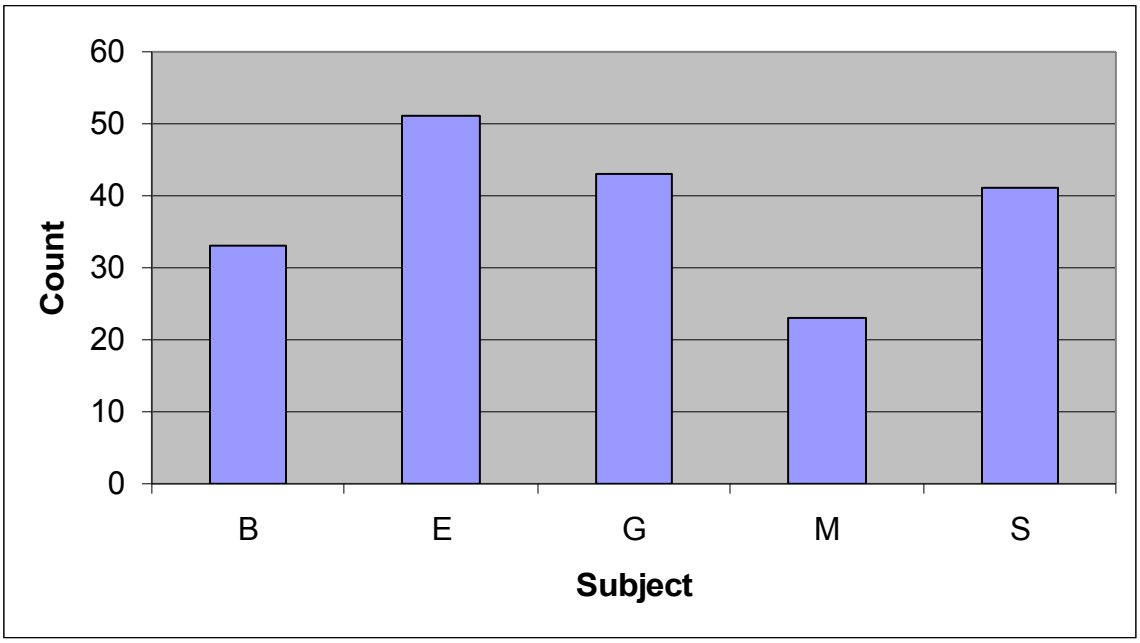

Figure 1: Number of Quotes Used By Subject

Preliminary findings

The following chart (Figure 2) shows the relative quantity of processing level coded paragraphs for each subjects, as well as the relative percentage for each subject. As can be seen, the Visceral level is substantially underrepresented, while the behavioral level is dominant, with the reflective level generally falling in between. The pattern of low visceral coding holds true for all participants. The pattern of higher behavioral and lower reflective frequencies holds true for all but one case (subject M).

[16] https://buy.garmin.com/shop/shop.do?pID=36728&ra=true (December 17th 2012)
[17] http://ibikesports.com/NEWTON.html (December 17, 2012)
[18] https://buy.garmin.com/shop/shop.do?cID=160&pID=69043 (December 17th 2012)

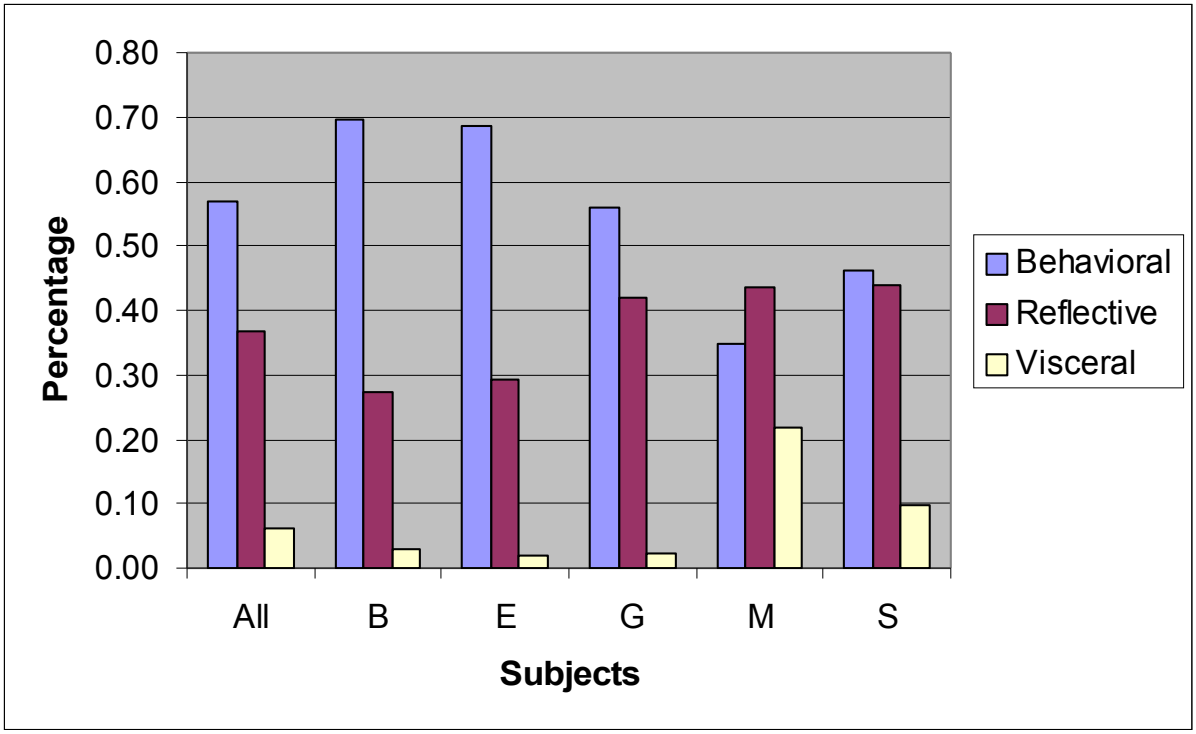

Figure 2: Emotional Attraction Coding Counts for all Subjects

It turns out that the difference between visceral and the other two values is statistically significant. A single-factor ANOVA returns a P-value of 0.000067. This is shown in Table 1, below

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Behavioral	5	2.752624	0.550525	0.022152
Reflective	5	1.859257	0.371851	0.006632
Visceral	5	0.388119	0.077624	0.007123

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.570216	2	0.285108	23.8207	6.63439E-05	3.88529
Within Groups	0.143627	12	0.011969			
Total	0.713843	14				

Table 1: Single-factor ANOVA of Behavioral, Reflective and Visceral Coded Frequency

Thinking about this, the question must be asked, "why is the visceral processing level so underrepresented?"

Lets start by looking at the other components, reflective and behavioral.

From a behavioral perspective, all subjects were primarily interested in having their devices work flawlessly. From S:

> *So that was a problem. Also it had different sensitivity to tree cover and stuff like that they tend to be a little less... it wasn't quite as good a track point recorder as the older guy is.*

Malfunctions and poor design were labeled as "frustrating" (B, G) "Awful" (E), and "Annoying" (B). Words that indicate malfunction such as "break", "broke", snapped, etc. appear throughout the interviews and are used by all subjects. A busted computer does not make for a nice ride.

A sub-element of behavior is price. For very good performance, subjects were willing to pay a premium. From M:

> *When I was on they diabolical double and there were several people in the ride that were using those these [Garmin Edge 800]. and they never got lost on the route. I had no idea they had turn by turn and it really worked until I saw people using it. I'm sure that you see the ads and they say that. And these things are stupidly expensive.*

Reflection in cycling typically involves data. The question of how far and how fast and how hard are always central to road riding. Note in this example how the data recorded by another persons' Gamin and posted on the website Strava.com becomes the cause for M to put in a high effort and post the result from his Garmin:

> *This route is like right down here. It's 2% up to the to the bridge and somebody put in a segment in the says it's a four category Hill. And I have to ride it every time I go to a ride so I rode it really, really hard one day and got that KOM [King of the Mountain] I haven't lost it, I don't think.*

This transference of the experience from the device to the experience is most accentuated in the visceral. Enough so the presence or absence of the device changes the experience of the ride. In other words, the ride remains at the center of the experience and the device remains at the periphery. From S:

> *You get used to a certain sensation. So if I don't have it, there is a feeling that one, you can't measure your performance for anything. It's similar to... If you take one of these guys instead of having it on your bar, you put it in your back pocket. And then seeing how you do. You get a different result than if you actually are looking at what you are doing*

Clearly, the viscerally attractive qualities of the bike computer are not driving the purchase of one computer over another. Rather it is the attraction of what these units can provide with respect to the ride. These cyclists are looking to enhance the experience of riding, both during the ride, and also afterwards, where these records serve much the

same purpose as photographs might record some other activity. But the visceral attraction here is from the experience of riding. A reasonable assumption to make is that the item that most affects the experience of riding is the rider, followed by the bicycle, with trip computers being further down the list.

Further reinforcing this interpretation is the role of tense. The proportional reference to the visceral level is highest in the past. For example appearance could be a detractor, from M, referring to a past Nike product (though it should be noted that this did not stop the purchase!):

> *And getting a this, this is the dorkiest thing you've ever seen.*

Visceral is relatively smaller in the present, and completely lacking in quotes having a future tense. The subjects literally did not think about how the visceral level of attraction would influence their purchase. Rather, the focus is on how the device affects the ride, both in the behavioral sense, as described by G:

> *I would buy one of those [GPS] in a heartbeat if it had a battery [that lasted long enough for Randoneurring].*

Or on the future role of reflection as part of riding, as described by B:

> *The sort of public riding as opposed to private riding. I mean a group ride is one thing you're all there your all they're doing it but, but, but when you use the Strava App, you're, you're competing against people even when you're riding by yourself.*

The relative proportions of quotes by tense is shown in Figure 3.

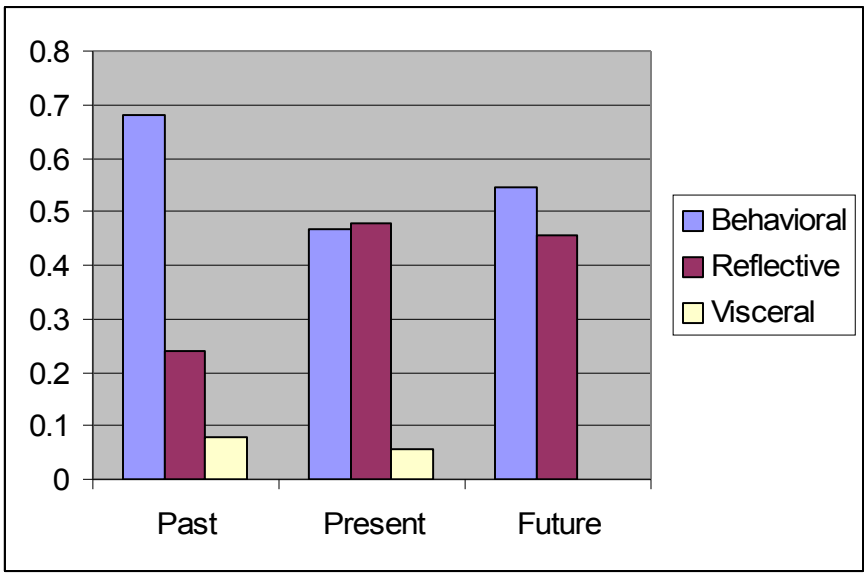

Figure 3, Percentage of Codes by Tense and Processing Level

This brings up a potentially interesting interpretation of the data. Where the experience is visceral and predominant, adoption of a device will be based on how the device supports the visceral experience. Furthermore, if the device is inexpensive, the user will have the opportunity to try many variations, and iteratively arrive at an optimal balance of price, behavioral and reflective processing.

Retrospective reflection

Upon reflection, I really want more time. This paper reads like a first draft, and I really would like another day or two to beat on it. But on the whole, I think I stumbled upon something interesting, that may be novel. I will probably rework this into a more presentable paper in the near future, and see where it could be submitted.

Although I do understand the perspective on qualitative studies and interpretive methods, I am still not convinced that this is a separate mechanism of research. I do believe that qualitative and quantitative methods will converge in the future, as computers begin to understand meaning and start to measure it. In some ways, this is happening already, as analytical tools become ever more powerful.

This is not a grounded study. Since it became a paper that analyzed the mapping of Norman's levels onto the five interviews, I was inasmuch forced to do the study that way. Still, I think that more may be gained by combining multiple information sources. I think the key is being able to explain the mapping to the subjects and see if they agree. I'd like to do this, but given the time constraints, that has not been possible.

The interview process was particularly enlightening. As a result, I have become a fan of having very loosely structured interviews. The emergent quality that a (relatively) open conversation can have is a deeply interesting thing. It is probably the one thing I'll truly remember from this class in ten years. If I had done this as a survey, I doubt that I would have found anything truly new. That being said, a survey might be the thing to do next?

I do find the idea of triangulation particularly important, and have tried to do it here with the addition of a bit of statistics. For me at least, the ability to use mixed methods so that one element may reinforce the other seems particularly useful and actually profound. That intersection of description and frequency analysis to validate the description seems to me to be a powerful way of reinforcing or correcting intuition.

Expectations for continued research on this topic

Since this concept of "Experience Augmenting Ubiquitous Computing" seems potentially valid, I'd like to see if it occurs in other areas for example, cell phone cameras are undergoing very rapid evolution as photography changes from the process of photographing *things* to recording *experiences*. Does one influence the other? If so how? Are there implications for design? Other areas include video game controllers and toys.