

What do Mobile Users Really Carry and Use?

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Abstract

When building mobile systems, it is frequently invaluable to have good answers to questions such as “What mobile devices do users carry?”, “What tasks do users do on their mobile devices?”, and “Why do they use some devices more than others?” etc. Unfortunately, obtaining these answers is hard and usually requires some sort of judgement call on the part of the research team. In this paper, we present the design of an online survey that attempts to tease out the answers to these questions and more from the general population. We present initial results from 58 respondents that both highlight some interesting patterns and demonstrate the survey’s potential in the longer term.

1. Introduction

I think everybody wants one mobile device for everything. Lets build everything based on this assumption!

No. No. No! People still want specialised devices for some tasks. An all-in-one device is doomed to fail!

As researchers in the mobile computing domain, we frequently encounter situations similar to the two stated above. We have to make a judgement call on what type of devices end-users (as opposed to the manufacturers of devices) actually prefer – all-in-one or specialised individual devices.

Unfortunately, having accurate answers to this question and related questions such as “What mobile devices do users carry?”, “What tasks do users do on their mobiles devices?”, “Why do they do these tasks on some devices and not others”, “Is there significant differences between genders, age groups, professions, etc. in terms of device usage?”, etc. is vital for any mobile system builder. In addition, do users prefer all-in-one devices that do everything (e.g., cellphone with mp3 and digital camera functionality) or specialised devices that do one thing well? Currently, system builders have to use their best judgement to pick answers to these questions.

In this paper, we describe the design, implementation, and analysis of an online survey that attempts to tease out answers to these questions. This survey was developed iteratively over a period of 14 months and was deployed live in September 2008 (located at <http://athena.smu.edu.sg>) – garnering responses from 58 users. Our initial analysis of the results collected from these respondents, presented in this paper, shows great promise. We are confident that the ongoing survey and analysis process will yield invaluable results for system builders.

2. Survey Design

We designed the survey to be web-based and take about 25 to 35 minutes to complete. It was built using Ruby-on-Rails (which allowed us to make the survey completely dynamic). Each participant first has to agree to the terms and conditions of the survey and give their consent to take part in it. The main survey itself comprises of six parts:

Part 1 – Demographics: In this part, each participant provides their demographic information. We collect email, age, gender, and country where they are located from everyone. In addition, we col-

lect, school, major, and year of study from students, and occupation and company from professionals. Table 1 shows the demographics information of the 58 respondents for this round of the survey.

Part 2 – Device Ownership: In part 2, we ask users to state what mobile devices they own. We allow them to specify up to five of each type of device. Our survey allows them to specify cell phones, mp3 players, watches, digital cameras, video cameras, laptops, standalone PDAs, GPS/Map devices, portable game devices, portable video players, travel alarm clocks, and others (they tell us what the device is). For each device they specify, they also have to provide their perceived proficiency level with the device (Poor, Low, Average (Default), Good, Exceptional), how frequently they use the device (many times during the day, at least once every day, at least once every 2–3 days, at least once a week, at least once a month, at least once every few month, only when I need to (Rarely), never), and how often they carry the device with them (always (> 99% of the time), Most of the time (75% – 99% of the time), often (50% of the time), infrequently (25% – 50% of the time), rarely (1% – 25% of the time), never (< 1% of the time)).

We selected the possible list of device types based on our own experiences and from an informal sampling of students. The summary statistics of the devices owned by the survey respondents is shown in Table 1.

Part 3 – Tasks Performed: In this part, we ask participants to state what tasks they do on the devices specified in Part 2. For each device, we provide the user with eighteen choices, separated into five logical groups as shown in Figure 8a. The logical groups are Time (“Tell the Time”, “Set Alarm”), Communication (“Make & Receive Phonecalls”, “SMS”, “Read Email”, “Write Email”), Entertainment (“Listen to Music”, “Look at Photos/Videos”, “Take Photos”, “Take Videos”, “Play Games”), Internet (“Browse the Web”, “Download Content/Media/Applications”, “Social Networking”), and Other (“Navigation (using GPS)”, “Read/Write Documents”, “Personal Finance”, “Store Data for Mobile Use”).

We initially started with far more than eighteen possible tasks. We then reduced the task list by combining uncommon tasks together (“Reading/Writing Documents” instead of “Read Documents” and “Write Documents” for example) and eliminating tasks that had low perceived utility (“Edit Video” for example). Similar to task 2, we used our own experiences coupled with input from initial test users to iteratively reduce the task list to the final eighteen.

For each task, the participant also had to specify how often they performed the task on that device (“Very Often”, “Often”, “Not so Often”, “Rarely”, “Very Rarely”) and where they are most likely to perform this task (“No Particular Place / Everywhere” (default), “Home”, “School/Office”, “Overseas”, “Commuting”, “On a Plane / Boat”, “Shopping”, “Social Events”, “Important Events”, “Other”).

Part 4 – Why They Do What They Do: This part of the survey is the most complicated and it is different for every participant. In this part, we ask participants specific questions about their device and task usage to try to understand why they do certain things on certain devices (and also why they do not use certain devices or perform certain tasks). This part is split into five cases:

Case 1: In this case, we find all the tasks that are performed on more than one device (we only pick tasks that have a reasonably

Total Number	58
Gender	Male (33), Female (25)
Age	Min. (18), Max. (52), Average (23.56)
Occupation	Students (45 Total – 18 Freshmen, 11 Sophomores, 8 Juniors, and 8 Seniors), Professionals (13)
Devices Owned (% of Respondents Owning Device)	Cellphone (100%), MP3 Player (58%), Digital Camera (83%), Mapping Device (10%), Laptop (100%), PDA (2%), Gaming Device (17%), Watch (62%), Alarm Clock (2%), Video Player (4%)

Table 1: Demographic Statistics for Survey

high frequency of usage). We then ask the participant to tell us why they do this task on multiple devices. Figure 8b shows the options that we give the participant for this type of question.

Case 2: In case 2, we find all the devices that are used for many tasks (again, we only use tasks that have reasonably high frequencies). We then ask the participant why she uses one device to do many tasks (as shown in Figure 8c).

Case 3: In case 3, we find all the devices that do one and only one task. This is a special corner case of cases 1 and 2 described above. Figure 8d shows the questions we ask for this case.

Case 4: This is a degenerate case where we ask the participant why they do not perform a specific task (i.e., the participant did not select one of the eighteen tasks for any of her devices). Figure 8e shows the questions asked for this case.

Case 5: Case 5, questions shown in Figure 8f, is the final degenerate case. This case happens when the participant does not select any tasks for one of their mobile devices.

Overall, the answers to these five cases allow us to understand, in more detail, why the participants do certain tasks on certain devices and why some devices and / or tasks are not used / performed. To avoid overloading the participants with numerous questions and exceeding our time goal of 25 to 35 minutes, we limit the numbers of questions asked in this part of the survey. We limit our total number of questions in this part to eight questions and bias our selection algorithm towards case 1, 2, and 3 questions. However, we ensure that we ask at least one case 4 and case 5 question (each) if the situation allows those questions to be asked.

Part 5 – General Opinions About Convergence and Divergence: In the previous parts, we asked participants to tell us exactly what they own, what they do, and why they do it. In this part, we try to understand how the participant feels about specialised and multi-function devices in general.

This part has two sections. In the first section, we ask the participant to give their opinions about general aspects of the convergence and divergence debate. In particular, as shown in Figure 8g, we ask each participant to agree or disagree with various questions about all-in-one and specialised devices. In addition, we ask them to tell us whether the number of mobile devices they had in the last year has increased, decreased, or remained the same and whether they expect the number of mobile devices they own to increase, decrease, or remain the same in the next one year.

In the second section, we ask 50% of the participants to tell us the top five factors that they use when choosing a specialised device (Figure 8h). The other 50% are asked to provide their top five factors when choosing a specialised device.

Part 6 – General Comments: In this final part, we provide the users with a large text box for them to enter any general comments they had about the survey.

3. Analysis of Results

Figure 9 summaries the task usage pattern of survey participants

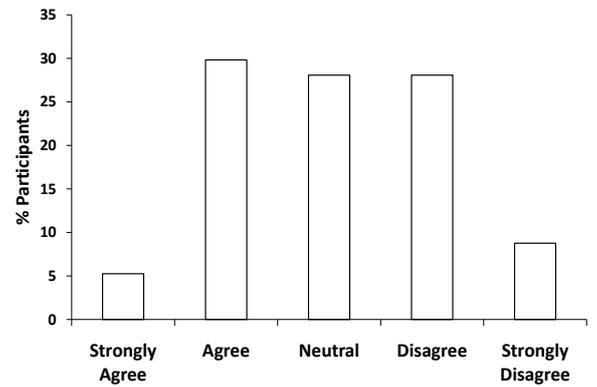


Figure 1: Prefer One Device That Does Everything

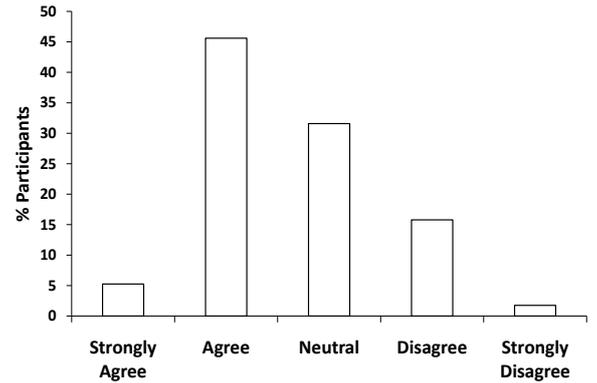


Figure 2: Prefer Best Device

on their mobile phones. Although the survey captured task usage on several other mobile devices, mobile phones were the only device type owned and extensively used by all the survey participants (see Table 1) in this phase of our data collection effort. Apart from the regular phone related functions (call and message related), we notice that photos, music and game related functions are the other heavily used features. Business functions related to emails, documents, and finance received low usage in this sample.

Figures 1 and 2 show the self reported preference of the survey participants for all-in-one or specialised devices respectively. The survey responses do not show any clear demarcation for the choice of either an all-in-one or specialised device. We analysed if there were significant differences in the preference for all-in-one or specialised devices across the demographic variables (gender, age, occupation) and self reported proficiency scores of the respondents but did not find any statistically significant differences among them.

To further understand the factors that could lead mobile users to prefer all-in-one or specialised devices, we analysed the beliefs and perceptions that users have on the complexity, quality, reliability, and price of these devices (collated survey scores shown in Figures 3 – 6). Figure 7 shows the top factors that users consider while buying an all-in-one mobile phone.

In the next step, we performed a series of regression analysis to understand the impact of the beliefs and perceptions of users on their preference for all-in-one or specialised devices. These results are presented in Table 2. For the regression analysis we considered both the entire sample (58 respondents) as well as a refined sample (30 respondents). The refined sample was derived from the whole sample by removing responses from users who were indifferent in their preference for all-in-one or specialised devices. We also performed a series of regression diagnostic checks (outlier analysis, checks on normality, multicollinearity) and confirmed that

Independent Variables	Regression Coefficients			
	Whole sample; Dependent Variable: Preference for all-in-one device	Whole sample; Dependent Variable: Preference for specialised devices	Refined sample; Dependent Variable: Preference for all-in-one device	Refined sample; Dependent Variable: Preference for specialised devices
I don't care how many devices I carry	-0.12	0.09	-0.32**	0.12
I buy devices without caring about tasks	0.49**	0.28**	0.31*	0.15
I find devices that do many tasks complex to use	-0.05	0.34***	-0.33*	0.47***
I believe devices that do many tasks are cheaper than buying multiple devices	0.22*	-0.08	-0.20	-0.18
I believe devices that do many tasks have similar quality relative to specialised devices	-0.09	0.01	-0.13	-0.16
I prefer devices that do many tasks as they have longer battery life	0.43***	-0.05	0.67**	-0.06
I believe devices that do many tasks are as reliable as specialised devices	-0.14	-0.01	-0.33*	0.16
Constant	0.70	0.70	3.91***	1.33
	Model significance F-Test: F(7, 50)= 6.65***; R-Squared = 0.48	Model significance F-Test: F(7, 50)= 5.34***; R-Squared = 0.42	Model significance F-Test: F(7, 22)= 3.26***; R-Squared = 0.51	Model significance F-Test: F(7, 22)= 2.11*; R-Squared = 0.40

results significant (using two-tailed tests) at 10% are indicated by *; significant at 5% indicated with **; at 1% indicated with ***. lightly shaded results are not significant.

Table 2: Impact of Belief and Perceptions on Device Choice

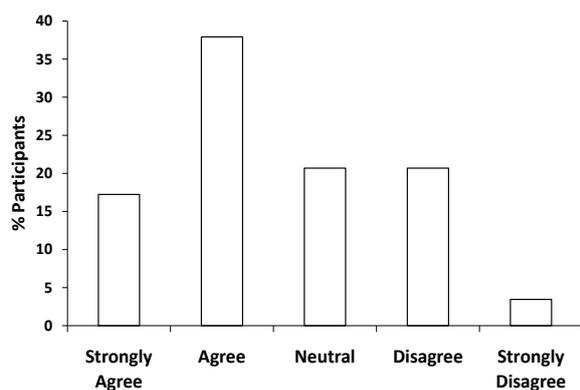


Figure 3: Multifunction Devices are Too Complex

there were no violations in our regression model specifications. We used ordinary-least-squares estimation to get the regression results presented in Table 2.

The regression results indicate that the user perceptions about the complexity of use is a chief factor that leads users to pick specialised or all-in-one devices for their mobile tasks. We find that respondents who prefer specialised devices for their tasks found all-

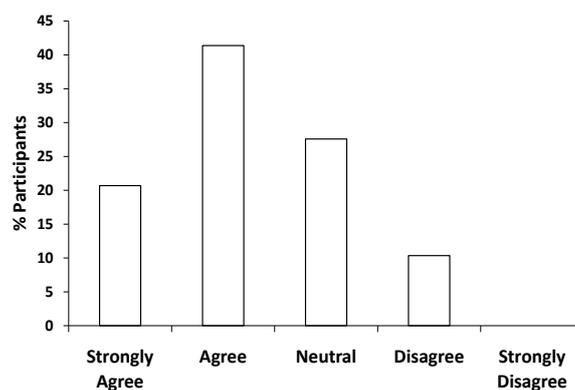


Figure 4: Multifunction Devices are Cheaper

in-one devices too complex to use. This result also correlated well with the fact that "user interface" ranks second among the dozen of other device characteristics for all-in-one devices (Figure 7).

A positive perception on the longevity of battery life in all-in-one devices was another significant result that swayed users towards all-in-one devices (Battery-life was ranked third important factor influencing purchase in Figure 7 and (43% of the whole sample

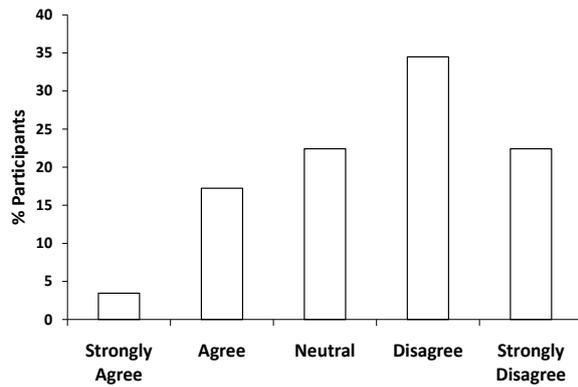


Figure 5: Multifunction Devices Have Similar Quality

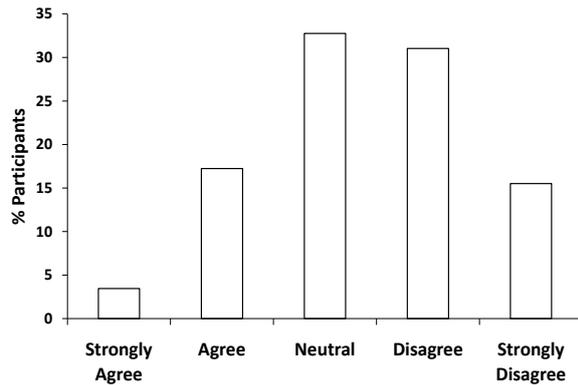


Figure 6: Multifunction Devices are as Reliable

(row 7 in Table 2) who wanted battery life picked all-in-one devices as their preferred option; 67% of the refined sample picked all-in-one devices). Also, we see that users who purchase mobile devices without carefully analysing their own task patterns tend to pick all-in-one devices (49% of the whole sample preferring all-in-one devices compared to just 28% preferring specialized devices; 31% of the refined sample preferring all-in-one devices while the percentage preferring specialized devices was not significant).

4. Related Work

Forman and Zahorjan [4] and Satyanarayanan [9] highlight the challenges of mobile computing that we draw inspiration from for this study. Sarker and Wells's [8] exploration of the factors that impact the use and adoption of mobile handheld device helped us design the task usage and user perceptions section of the survey. Mahatanankoon et. al [6] analysed the impact of both the technological factors and factors related to trust on mobile device usage from a technology acceptance model theoretical perspective. Benbunan-Fich and Benbunan [2] analyse user behaviour in using applications loaded on the mobile devices. Kleijnen et. al [5] also investigate the factors influencing the adoption of one set of mobile applications related to gaming services and mobile commerce. Constantiou et. al [3] investigate the differences in use of mobile services among users in an advancing market.

Our survey design draws inspiration from these related studies in capturing user perception of technological features, as well as their actual usage behaviour on the devices they currently own. Our focus is on relating the user task patterns on mobile devices with user beliefs and perceptions to break new ground in understanding the equilibrium between all-in-one multitasking devices,

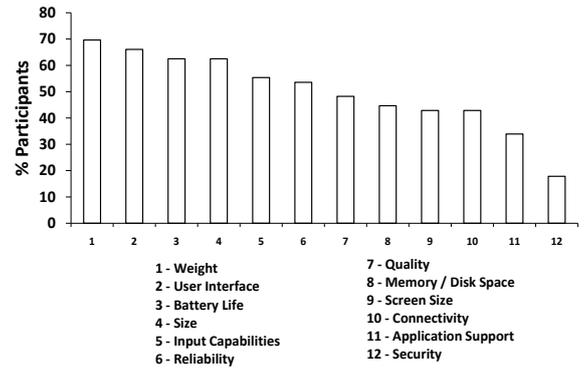


Figure 7: Factors Influencing All-in-One Device Purchase

specialised devices, and user requirements.

On a more personal note, the idea of this survey was conceived due to the personal experiences of the authors in building mobile systems (e.g. Balan et. al [1] and Peek and Flinn [7]). Concrete data concerning mobile device usage and patterns would have been highly beneficial to us when building those systems – possibly resulting in even better systems.

5. Conclusion

In this paper, we presented the results of an online survey that attempts to provide answers to questions such as “What mobile devices do users carry?”, “What tasks do users do on their mobile devices?”, and “Why do they use some devices more than others?”. These questions are highly relevant to mobile system developers and will have an impact on the kinds of systems that we develop.

Our survey is an ongoing initiative and we are constantly refining and improving it. In addition, we will soon deploy the survey to even more users in Singapore (the other universities and a larger general population audience) as well as users in America (mainly located at the University of Michigan and Carnegie Mellon University) and India (mainly located at the IT hubs of Bangalore and Hyderabad). As such, we expect to have a lot more data to analyse in the next few months. Finally, interested parties who wish to deploy the survey in their local environments are invited to contact the authors at their earliest convenience.

6. References

- [1] Balan, R. K., Gergle, D., Satyanarayanan, M., and Herbsleb, J. D. Simplifying cyber foraging for mobile devices. *Proceedings of the 5th International Conference on Mobile Systems, Applications, and Services (MobiSys)*, San Juan, Puerto Rico, June 2007.
- [2] Benbunan-Fich, R. and Benbunan, A. Understanding user behavior with new mobile applications. *The Journal of Strategic Information Systems*, 16(4):393–412, Dec. 2007.
- [3] Constantiou, I. D., Damsgaard, J., and Knutsen, L. User differences in an advancing market. *International Journal of Mobile Communications*, 4(3):231–247, Feb. 2006.
- [4] Forman, G. and Zahorjan, J. Survey: The challenges of mobile computing. *IEEE Computer*, 27(4):38–47, April 1994.
- [5] Kleijnen, M., de Ruyter, K., and Wetzels, M. G. M. Factors influencing the adoption of mobile gaming services. pages 202–217, 2003.
- [6] Mahatanankoon, P., Wen, H. J., and Lim, B. B. Evaluating the technological characteristics and trust affecting mobile device usage. *International Journal of Mobile Communications*, 4(6):662–681, July 2006.
- [7] Peek, D. and Flinn, J. EnsembleBlue: Integrating distributed storage and consumer electronics. *Proceedings of the 7th USENIX Symposium on Operating System Design and Implementation (OSDI)*, Seattle, WA, Nov. 2006.
- [8] Sarker, S. and Wells, J. D. Understanding mobile handheld device use and adoption. *Communications of the ACM*, 46(12):35–40, Dec. 2003.
- [9] Satyanarayanan, M. Pervasive computing: Vision and challenges. *IEEE Personal Communications*, 8(4):10–17, Aug. 2001.

Step 3/6: Usage Pattern

Back to Step 2

HTC Touch Pro (Mobile Phone)
You carry this device most of the time (75-99% of the time).
You use this device many times during the day.
Do you use this device for the following tasks:

Time:
 Tell the Time
How often? (When using this device)
Where?

Set Alarm

Communication:
 Make & Receive Phonecalls
 SMS
 Read Email
 Write Email

Entertainment:
 Listen to Music
 Look at Photos / Videos
How often? (When using this device)
Where?

Take Photos
 Take Videos
 Play Games

Internet:
 Browse the Web
 Download Content/Media/Applications
 Social Networking (e.g. Facebook)

Other:
 Navigate (using GPS)
 Read/Write Documents
 Personal Finance
 Store Data for Mobile Use

Next Device

a) Part 3

Step 4/6: Additional Usage Questions

Back to Step 3

HTC Touch Pro (Mobile Phone)

Why do you use the HTC Touch Pro(Mobile Phone) to do 3 tasks? (Check all that apply) Tell the Time, Make & Receive Phonecalls, SMS

It is more secure / private to do these tasks on this device.
 It is cheaper for me to do these tasks on one device.
 This device gives adequate task speed for all these tasks.
 This device is easy to carry.
 This device gives adequate task accuracy for all these tasks.
 This device gives adequate overall task quality for all these tasks.
 Acquiring required data to do these tasks on this device is easy.

These device characteristics makes the HTC Touch Pro a suitable device for the above mentioned tasks? (Check all that apply)

Input capabilities
 Security
 User interface
 Quality
 Battery Life
 Memory / disk space
 Size
 Reliability
 Weight
 Connectivity
 Screen size
 Application support

Other:

Next Device

c) Part 4 – Case 2

Step 4/6: Additional Usage Questions

Back to Step 3

Time

Why don't you Set Alarm on any of your mobile devices? (Check all that apply)
I forgot to select this task [Go Back to Step 3](#)

It is expensive to do this task on my Mobile Devices (Power, Usage Charges etc).
 No mobile device I own can do this task with adequate security / privacy.
 I plan to do this task in the future.
 I do this task on a non-mobile device.
 This task is really hard to do on the mobile devices I own.
 This task is not important to me.
 This task cannot be done with adequate speed on any mobile device I own.
 I do not own any mobile device that can do this task.
 This task cannot be done with adequate task accuracy on any mobile device I own.
 Devices to do this task are too expensive for me to own.
 This task cannot be done with adequate quality on any mobile device I own.

Other:

Next Category

e) Part 4 – Case 4

Step 5/6: Opinions

Back to Step 4

Rate the following opinions: (1-Strongly Agree 5-Strongly Disagree)

1) I prefer to use the best device for each task, even if that means carrying multiple devices.
 Strongly Agree Agree Neutral Disagree Strongly Disagree

2) I prefer to use one device to do multiple tasks, even if that device is not the best one to use for every task.
 Strongly Agree Agree Neutral Disagree Strongly Disagree

3) I don't care how many devices I carry.
 Strongly Agree Agree Neutral Disagree Strongly Disagree

4) I buy devices without caring about tasks.
 Strongly Agree Agree Neutral Disagree Strongly Disagree

5) I find devices that do many tasks complex to use.
 Strongly Agree Agree Neutral Disagree Strongly Disagree

6) Devices that do many tasks are cheaper than buying multiple devices.
 Strongly Agree Agree Neutral Disagree Strongly Disagree

7) Devices that do many tasks have similar quality relative to specialized devices.
 Strongly Agree Agree Neutral Disagree Strongly Disagree

8) I prefer devices that do many tasks as they have longer battery life.
 Strongly Agree Agree Neutral Disagree Strongly Disagree

9) Devices that do many tasks are as reliable as specialized devices.
 Strongly Agree Agree Neutral Disagree Strongly Disagree

Device Ownership

1) In the last year, did you the number of devices you own
 increase decrease stay the same?

2) In the next year, will the number of devices you own
 increase decrease stay the same?

Continue

Back to Step 4

g) Part 5 – Section 1

Step 4/6: Additional Usage Questions

Back to Step 3

Time

You have indicated that you use 3 devices to Tell the Time

When would you prefer to use your HTC Touch Pro(Mobile Phone) over the other devices indicated to Tell the Time? (Check all that apply)

Home
 School/Office
 Overseas
 Commuting
 On a plane/boat
 Shopping
 Social Events
 Important Events

Other:

Why? (Check all that apply)

Input capabilities
 Security
 User interface
 Quality
 Battery Life
 Memory / disk space
 Size
 Reliability
 Weight
 Connectivity
 Screen size
 Application support

Other:

b) Part 4 – Case 1

Step 4/6: Additional Usage Questions

Back to Step 3

ipod (Mp3 Player)

Why do you just use the ipod(Mp3 Player) to just Listen to Music? (Check all that apply)

I only have one device that does this task.
 Acquiring required data to do this task on multiple devices is painful.
 Maintaining data consistency for this task on multiple devices is painful.
 It is more secure / private to do these tasks only on this device.
 This device gives adequate task speed for this task.
 This device gives adequate task accuracy for this task.
 This device gives adequate overall task quality for this task.
 This is a specialized device.
 This device is easy to carry.

These device characteristics makes the ipod a suitable device for the above mentioned task? (Check all that apply)

Input capabilities
 Security
 User interface
 Quality
 Battery Life
 Memory / disk space
 Size
 Reliability
 Weight
 Connectivity
 Screen size
 Application support

Other:

Prev Device Continue

d) Part 4 – Case 3

Step 4/6: Additional Usage Questions

Back to Step 3

Time

Why don't you Set Alarm on any of your mobile devices? (Check all that apply)
I forgot to select this task [Go Back to Step 3](#)

It is expensive to do this task on my Mobile Devices (Power, Usage Charges etc).
 No mobile device I own can do this task with adequate security / privacy.
 I plan to do this task in the future.
 I do this task on a non-mobile device.
 This task is really hard to do on the mobile devices I own.
 This task is not important to me.
 This task cannot be done with adequate speed on any mobile device I own.
 I do not own any mobile device that can do this task.
 This task cannot be done with adequate task accuracy on any mobile device I own.
 Devices to do this task are too expensive for me to own.
 This task cannot be done with adequate quality on any mobile device I own.

Other:

Next Category

f) Part 4 – Case 5

Step 5/6: Opinions

Back to Step 4

When deciding to buy a specialized mobile device (i.e. a device that primarily does only one thing -- like take photos, or show maps for example), What factors do you consider? Please give at least three factors (up to a maximum of five factors).

1.

2.

3.

4.

5.

Continue

Back to Step 4

h) Part 5 – Section 2

The Screenshots for Parts 1 and 2 have been omitted. The help text for each part is also not shown.

Figure 8: Survey Screenshots

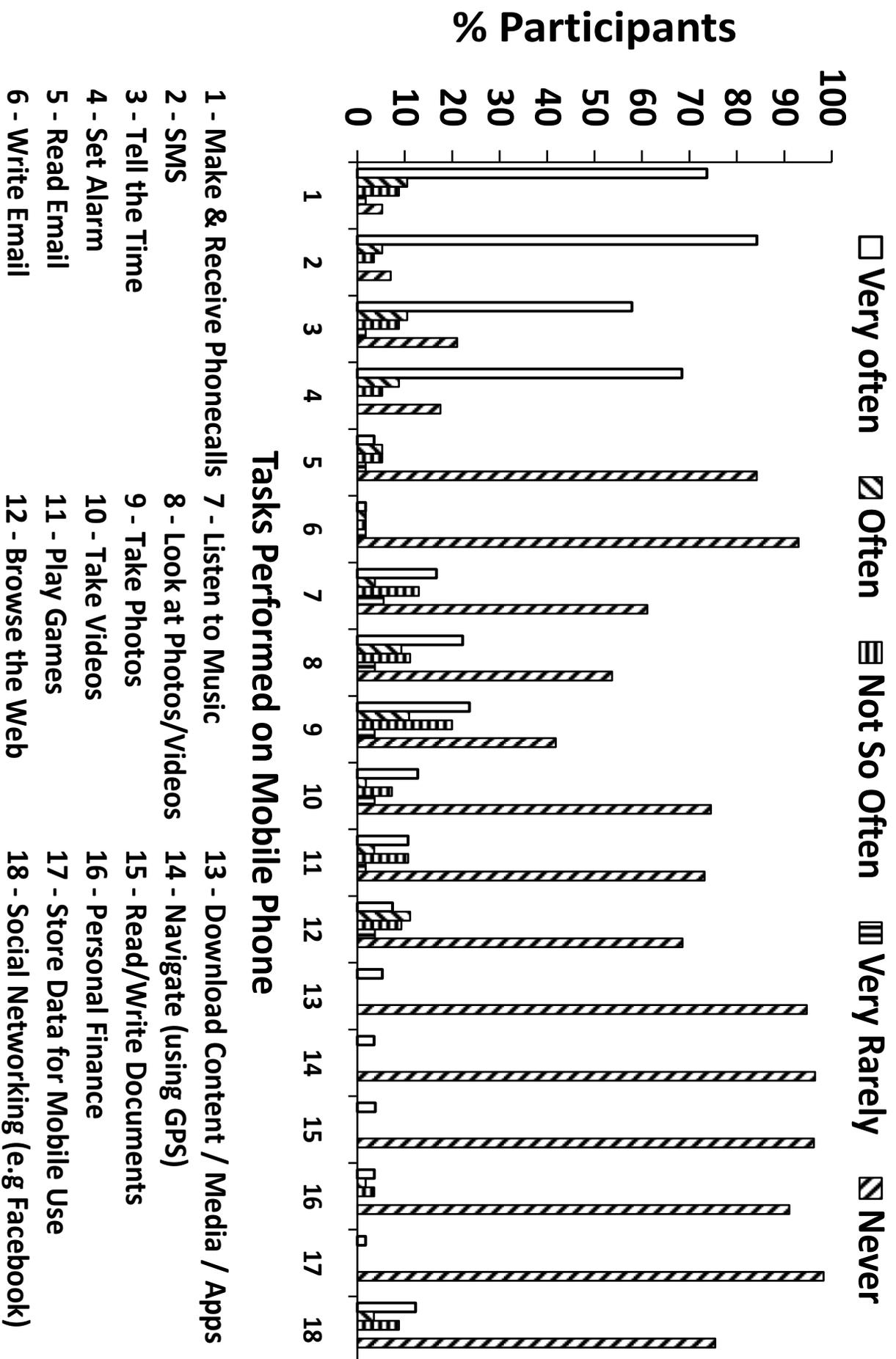


Figure 9: Mobile Phone Task Usage