A comparative analysis of the ergonomic anthropometry and usability of locally designed and foreign designed smartphones.

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Abstract

Nowadays, mobile phones have become an essential tool for people’s everyday lives. In designing smartphones, various factors are to be considered. People usually prefer smartphones which are user friendly and is a good tradeoff between price and functionality. One of the traits that Filipinos have in this generation is their patronage to foreign designed and manufactured gadgets and smartphones. Since those devices are designed abroad, it is possible that they are only manufactured for the optimal usability of the users of the country where they are manufactured from. Hence, there is a possibility that the physical design and dimensions do not conform to the Filipino users due to the differences in the anthropometric measurements between races, specifically in the measurement of the hands and fingers resulting to awkward positioning of the hands or being unable to grip the smartphone properly when using the smartphones. In this study, the proponents conducted a comparative analysis of ergonomic anthropometry and usability of locally designed and foreign designed smartphones. The researchers gathered the most commonly used locally designed and foreign designed smartphones that Filipino use and their corresponding dimensions and physical design. The results showed that the top 2 most frequently used foreign designed brands are Apple and Samsung and locally designed brands are Myphone and Cherry Mobile. For the uniqueness of model, the latest LG smartphone was also considered. The researchers gathered the dimensions and the distances from the bottom left corner left and the bottom right corner of the smartphone to the physical buttons such as the power, volume, home, multitask, back, silent buttons, and the status bar.

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1. Introduction

People nowadays, especially those who are living in the middle to the higher socioeconomic classes, own a smartphone, either made locally or abroad. Phones that have more computing capability and connectivity that can run thousands of different applications require more controls from the users. There has been a global increase in smartphone ownership and trend in the increase of its sizes has caused a necessity to provide designs that can be easily used by everyone. However, due to the different anthropometric measurements of people belonging to different nationalities, one design cannot accommodate every individual.

2. Problem Statement

One of the traits that Filipinos have in this generation is their patronage to foreign designed and manufactured products, specifically gadgets and smartphones. Since they are designed abroad, it is possible that they are only manufactured for the optimal usability of the users of the country where they are manufactured from. Hence, there is a possibility that the physical design and dimensions do not conform to the Filipino users due to the differences in the anthropometric measurements between races, specifically in the measurement of the hands and fingers resulting to awkward positioning of the hands or being unable to grip the smartphone properly when using the smartphones.

3. Methodology

3.1 Determination Smartphone Statistics

The researchers gathered data as to what is the most commonly used locally designed and foreign designed smartphones that Filipino use and their corresponding dimensions and physical user interface. The results showed that in terms of sales, price, and quality, Myphone, Cherry Mobile, Samsung and Apple are the top 4 brands in the list in that order. Coincidentally, two are foreign designed, namely Samsung and Apple while two are locally designed, namely Myphone and Cherry Mobile. Hence, the researchers would focus on these brands. Apart from that, a research conducted by Gartner shows that the top 2 brands in terms of worldwide smartphone sales to end users by vendor in 2013 are Samsung and Apple [1].

In another survey conducted by JANA, a Boston based mobile technology company, the top five smartphones in the Philippines in terms of sales are Nokia, Samsung, Cherry Mobile, Sony and Myphone. Among the top five, Cherry Mobile and Myphone are locally designed. For this reason, these brands will also be used for the study[2].

3.2 Gathering of Anthropometric Measurements.

Setting the confidence level at 95% and a limit of 10 in a population of approximately 3000 College of Engineering students, the researchers collected a sample of 100 students which measured the necessary anthropometric measurements for the both hands. Referring to Figure 4, point P is where the bottom of the smartphone is placed when used. The researchers measured the length P-1, P-2, P-3, P-4, and P-5 to be used for reach evaluation and lengths P-6, P-7, P-8, and P-9, the hand width, and length of segment 10 for grip level evaluation. The age and the gender of the student were also asked to prevent bias.
3.3 Gathering of Data Measurements from Selected Smartphones

The researchers gathered the dimensions of the different smartphones to use for the evaluation. In addition, different distances from specific points (lower right and left corners) to the different buttons and functions such as volume up and down, power, home button, etc. were also measured.

3.4 Usability Evaluation

From the gathered data, the type of distribution was obtained along with its relevant parameters. Based from the measurements and dimensions of the smartphones, the researchers computed the cumulative percentage of people that can press each buttons and functions using the reach measurement of the applicable fingers. By applicable, it means that it will not result to too much awkward position of the fingers. For example, no one will be able to use their pinky to press the home button. Lastly, the researchers will provide overall ergonomic score for each of the smartphones by getting the average of the percentages of those that can reach the power button, volume buttons, multitask, back, and home buttons.

4. Results and Discussion

Based from the anthropometric measurements of the hands of the samples, it was verified that the results follow a normal distribution. The following figure shows a sample of the normal distribution obtained from the samples.
Table 1. Dimensions of the Five Smartphones (in cm).

|               | Apple iPhone 6 | Samsung Galaxy S5 | Cherry Excalibur | Myphone Infinity Lite | LG G3 |
|---------------|----------------|-------------------|------------------|-----------------------|-------|
| **BODY**      |                |                   |                  |                       |       |
| Length        | 13.81          | 14.20             | 14.00            | 13.80                 | 14.63 |
| Width         | 6.70           | 7.25              | 7.00             | 6.80                  | 7.46  |
| Thickness     | 0.69           | 0.81              | 0.79             | 0.80                  | 0.89  |
| **SCREEN**    |                |                   |                  |                       |       |
| Length        | 10.37          | 11.46             | 11.08            | 10.36                 | 12.55 |
| Width         | 6.02           | 6.87              | 6.22             | 5.78                  | 7.04  |
| **BODY TO SCREEN** |       |                   |                  |                       |       |
| Top to Screen | 1.72           | 1.37              | 1.46             | 1.72                  | 1.04  |
| Bottom to Screen | 1.72   | 1.37              | 1.46             | 1.72                  | 1.04  |
| Left to Screen | 0.34          | 0.19              | 0.39             | 0.51                  | 0.21  |
| Right to Screen | 0.34          | 0.19              | 0.39             | 0.51                  | 0.21  |
| **BUTTONS**   |                |                   |                  |                       |       |
| Power         | 12.14          | 12.22             | 11.68            | 11.26                 | 11.48 |
| Home          | 3.02           | 3.30              | 3.34             | 3.25                  | 12.31 |
| Volume Up     | 10.26          | 11.48             | 10.33            | 10.04                 | 10.85 |
| Volume Down   | 9.08           | 10.32             | 9.70             | 9.47                  | 3.75  |
| Silent        | 11.66          | -                 | -                | -                     | -     |
| Status Bar    | 12.03          | 12.87             | 12.25            | 12.04                 | 13.63 |
| Multitask     | -              | 1.42              | 1.71             | 1.67                  | 5.87  |
| Back          | -              | 5.40              | 5.05             | 4.94                  | 2.02  |
| Grip          | 9.48           | 10.25             | 9.90             | 9.62                  | 10.55 |

Table 1 shows the dimensions of the five brands selected. LG G3 is the longest and has the highest screen length, followed by Samsung Galaxy S5, Cherry Excalibur, Apple iPhone 6, and Myphone Infinity Lite. In terms of body and screen width, LG G3 still tops the list, followed by Samsung Galaxy S5, Cherry Excalibur, Apple iPhone 6, and Myphone Infinity Lite. And lastly, in terms of thickness, LG G3 still tops the list, followed by Samsung Galaxy S5, Myphone Infinity Lite, Cherry Mobile Excalibur, and Apple iPhone 6. These dimensions, as well as the anthropometric data gathered would be used in computing for the percentage of comfortability of the population for both the left and right hands.

The term percentage of comfortability is assigned to the percentage that represents how much of the expected population could select a certain button comfortably without changing his/her hand position using one hand only. For example, a 75 percentage of comfortability for the Samsung Galaxy S5’s volume up button means that 75% of the sample can comfortably select the volume up button when using the Samsung Galaxy S5 with one hand.
Despite the significant difference of anthropometric data between males and females, their data has been combined for the study and the computations. This is due to the fact that the selected mobile phone products are not gender specific in terms of targeting their market, as well as that gender is not a relevant factor in purchasing smartphones. As both data follow the same type of distribution, a unified study with both genders does not become significantly more difficult. Equal samples for male and female remove any bias towards gender as well. The samples of the step by step iterations of tables to arrive at the results are shown below:

Table 2. Sample Mean and Standard Deviation of Left Hand Anthropometric Measurements (in cm).

| Finger | TIPS | RIDGES |
|--------|------|--------|
| Mean   | 11.86| 11.319 |
| St. Dev| 1.105| 1.07   |

Shown are the sample parameters obtained from the anthropometric data. These, along with the phone dimensions and measurements, were necessary to compute the cumulative percentiles of the sample able to reach certain phone buttons. The sample below shows these percentiles for a few of the buttons and anthropometric measurements.

Table 3. Sample Percentiles for the Apple iPhone 6 using the Left Hand

| Distance from Corner | Pinky | Ring | Middle | Index |
|----------------------|-------|------|--------|-------|
| Power                | 12.14 | 0.0079| 0.2206 | 0.4449|
| Home                 | 3.02  | 1.0000| 1.0000 | 1.0000|
| Volume Up            | 10.26 | 0.2987| 0.8388 | 0.9468|

Take note that the formula used was $1 - \text{Normal Distribution Function}$ to allow the percentiles to represent the sample of anthropometric data GREATER THAN the phone measurements as opposed to LESS THAN. Removing the percentiles wherein it is not applicable (i.e. the selected finger would never in any situation be used for the selected button) to the phone model, the proponents arrived at the following table:

Table 4. Sample Percentiles for the Apple iPhone 6 using the Left Hand (N/A Removed).

| Distance from Corner | Pinky | Ring | Middle | Index |
|----------------------|-------|------|--------|-------|
| Power                | 12.14 | 0.0079| 0.2206 | 0.4449|
| Home                 | 3.02  | 1.0000| 1.0000 | 1.0000|
| Volume Up            | 10.26 | 0.2987| 0.8388 | 0.9468|

The maximum percentile per row was selected, compiled, and multiplied by a hundred to obtain the final “Percentage Comfortable” table of results. This is under the principle that if at least one of the selected fingers are able to comfortably reach the selected button, it is assumed that the person is not at a discomfort in selecting the said button. The summary of the results are as follows:
Table 5. Summarized Results for the Left Hand (Percentage Comfortable).

|                  | Apple iPhone 6 | Samsung Galaxy S5 | Cherry Mobile Excalibur | Myphone Infinity Lite | LG G3 |
|------------------|----------------|-------------------|-------------------------|-----------------------|-------|
| Power            | 44.49          | Power             | 41.71                   | Power                 | 61.66 |
| Home             | 100.00         | Home              | 100.00                  | Home                  | 100.00|
| Volume Up        | 45.09          | Volume Up         | 9.15                    | Volume Up             | 93.94 |
| Volume Down      | 85.36          | Volume Down       | 42.55                   | Volume Down           | 98.35 |
| Silent           | 6.55           |                   |                         |                       |       |
| Status Bar       | 2.98           | Status Bar        | 0.33                    | Status Bar            | 1.76  |
| Multi-Task       | 100.00         | Multi-Task        | 100.00                  | Multi-Task            | 100.00|
| Back             | 100.00         | Back              | 100.00                  | Back                  | 100.00|
| Grip             | 99.04          | Grip              | 94.74                   | Grip                  | 97.43 |
| Average          | **54.79**      |                   | **61.06**               | **81.64**             | **84.06**|

Table 6. Summarized Results for the Right Hand (Percentage Comfortable).

|                  | Apple iPhone 6 | Samsung Galaxy S5 | Cherry Mobile Excalibur | Myphone Infinity Lite | LG G3 |
|------------------|----------------|-------------------|-------------------------|-----------------------|-------|
| Power            | 55.48          | Power             | 73.13                   | Power                 | 88.50 |
| Home             | 100.00         | Home              | 100.00                  | Home                  | 100.00|
| Volume Up        | 45.74          | Volume Up         | 7.87                    | Volume Up             | 99.94 |
| Volume Down      | 78.49          | Volume Down       | 29.58                   | Volume Down           | 100.00|
| Silent           | 11.44          |                   |                         |                       |       |
| Status Bar       | 2.69           | Status Bar        | 0.18                    | Status Bar            | 1.43  |
| Multi-Task       | 100.00         | Multi-Task        | 100.00                  | Multi-Task            | 100.00|
| Back             | 100.00         | Back              | 100.00                  | Back                  | 100.00|
| Grip             | 99.01          | Grip              | 94.71                   | Grip                  | 97.38 |
| Average          | **56.12**      |                   | **63.18**               | **85.91**             | **86.74**|

The percentage pertains to the percentage of the population that can comfortably reach the given buttons and grip the smartphone. Given the two tables, it could be observed that for the left hand, LG G3 has the highest average percentage, followed by Myphone Infinity Lite, Cherry Mobile Excalibur, Samsung Galaxy S5, and Apple iPhone 6. On the other hand, for the right hand, Myphone Infinity Lite has the highest average percentage, followed by LG G3, Cherry Mobile Excalibur, Samsung Galaxy S5, and Apple iPhone 6. It could be observed that the right hand has higher average values as compared to the left hand. This may be due to the fact that there are more right handed people than left handed people in the sample. The comparison is best shown below:
Another observation is that given that LG G3 has the largest length, width, and thickness, it also has the lowest percentage for grip. Extreme cases or those that are less than 25% of the sample for the five brands are in green. The status bar is consistent for the five brands, and the silent button for the Apple iPhone 6 is added. The result is consistent with the location of the status bar. Being at top edge of the screen could result to difficulty of using the function.

It could also be observed that the location of the buttons greatly affects the comfort percentage per brand. Since the home, multitask, and back buttons are near the bottom edge of the phone, there is no awkwardness in reaching for the given buttons whereas for the status bar, volume up, volume down, and the silent button in the Apple iPhone 6, there is a difficulty in reaching for those buttons. The results show that being able to reach a given function decreases with the increasing distance from the bottom of the phone. Also,-switching the position of the multitask and back buttons has no overall effect in the results.

It should also be noted that the smartphones tend to have their buttons placed at the right side of the phone. This can be attributed to the fact that there are more right-handed people than left-handed people. Hence, more people will benefit with the design being as such. This is especially true for the locally designed smartphones that only have buttons at the right side of the phone.

Lastly, the innovation of the LG G3 phone design has paid-off. Even if it is the largest of the five brands, putting the power, volume up, and volume down buttons within easier reach caused it to gain higher results, leveling to the Filipino counterparts. Though LG is a foreign designed brand, it has been deemed as ergonomic as local brands in the Philippines.

5. Conclusion

Of the five smartphones, the LG G3 and Myphone Infinity Lite showed the best results with the Cherry Mobile closely behind. The results showed that the two locally designed brands cater to the anthropometric measurement of the sample and hence are compatible with the hand measurements of the Filipino. Their buttons are easily reachable than their foreign counterparts. Lastly, LG G3, the biggest phone analyzed in the study can be made ergonomic to Filipino because of the innovative button placement.

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