Effect of Icon Concreteness, Semantic Distance and Familiarity on recognition level of mobile phone icons among E-literate and Non E-literates

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***ABSTRACT*:** *Cell phones have turn out to be the most central communication gadget in our daily life. This results in an enormously intense competition between almost all the mobile phone vendors. Despite of manufacturer's diverse types of advertising strategies such as exceptional price cut offers or modern attractive functions, what really matter is whether this everyday communication gadget has been designed according to the preference and requirements of all types of users. The miniature type screen interface design is one of the recent research themes of the Human-Computer Interaction domain. Because of the restricted screen size, "icons" have been considered as dominant part in usability of cell phones. This paper measures the recognition level of icons among e-literate and non-e-literate people. This article explores the effect of icon characteristic on recognition level of icons among e-literates and non e-literate users. It was found that designers of mobile phone icons have to balance a trade-off between the need, requirements and understanding of both e-literate and non e-literate users.*

Keywords : Human-computer interaction, Icon designing, Mobile phones

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1. Introduction

With the enhancement of technology, the communication devices like mobile phones are not limited to common applications of calling and texting they provide much more facilities now than ever before. These applications are represented through icons at the interface of small screen of mobile phones and smart phones to facilitate users to perform their everyday jobs. Visual facets, such as graphics display on the screen and icons, are fundamental rudiments of human-mobile interaction; they have been used in interface design in broader sense on the supposition that visual icons are adequate for handling impediments like language and present information in summarized form.

Literature has abundant evidence of analyzing the graphic illustrations by using icons for portable devices. Investigating the

level that any icon symbolizes the sense of the purpose for which it has been intended to design, selected and configured by the cell phone maker and designer, has attracted the researcher community at large. A large proportion of older adults (the non e-literate users) due to their aging, grow worse in many of their natural abilities, like perception, motor and abilities being or relating to or involving cognition, which limit the quality of moving freely and their independence, and hence requiring more support [1]. Cell phones can support non e-literate adults for staying connected online; remembering important information by the help of memory aids and portable games stimulates mental exercises and can even provide them fun [2]. However, as being non e-literate they have find these devices more difficult to use and slower to adopt mobile computer technologies. The reluctance of these non e-literate users to adopt mobile devices can be explained by the modern HCI investigations that has inspected various diverse usability issues [3], [4].

On the other hand, the situation from the perspective of younger users (e-literate users) is quite opposite. They are very enthusiastic and motivated to use these mobile devices for almost all tasks of their daily life. And, as they don't share any of the disabilities like the older users mentioned above, therefore they interact with these mobile devices in a quite easy way and in a fast pace.

The literature has evidence a very scarce work related to the investigations of the influence of graphical icons on e-literate and non e-literate user's use of portable equipment's, even though the icons are an integral part of the most user interfaces. The ability of older adults to interpret graphical icons is effected by the decline in perceptual and cognitive abilities accompanying with normal aging. The strength of interpreting the icons in older non e-literate users has also been affected by their low and narrow experience with contemporary handheld devices coupled with the less familiarity with a device's icons and applications.

This article investigates the effects of icon designs and styles employed by different vendors on the perception of both the e-literate users and non e-literate users. An online questionnaire containing 10 sets of icons (representing major functionalities) of a cell phone (total 50 icons, 5 in each set) was filled by 250 respondents. Quantitative methods were used to analyse the results. Below, in Section 2, various articles have been explored from the literature, summarizing their results of experimental validations. Section 3 illustrates the detailed methodology employed to perform the research. Section 4, analyses and discusses the results. Section 5, concludes the articles by presenting and summarizing the results.

2. Literature Review

Literature have evidenced much promising work on designing computer interfaces for non e-literate users (e.g. [5], [6], [7]), but less work has appeared specifically at the usability of computer icons. The literature has identified that many of the characteristics related to users has affected the usability of computer technology also affect the usability of icons for the group of non e-literate users. These user characteristics include attention, the capacity to learn and remember new information and associations, verbal and visual abilities. In addition to above, the icon usability may also be affected due to less experience with software interfaces by this age group.

The authors in [8] suggest a concrete icon design methodology for mobile base interface for the naïve low literate user segment. They also try to identify the key constructs under cognitive absorption which may have significant effect on behavioral intentions of low literate users. The authors revealed the relationships that exist between icon characteristics and different dimensions come under cognitive absorption. The author has advocated for metaphor driven icon design methodology for designing icon design interface for the low literate target. As practical contribution they offer clear design strategies for crafting coherent sequence effective user interactions which will facilitate self-initiated learning and usage of mobile base application.

In [9], guided by the two major goals the authors have conducted a research. To determine icons characteristics in the sector of mobile phone that ensures high semantic transparency was the first goal. The aim of this goal was to scrutinize Icons' visual complexity and concreteness. These two characteristics are in fact the important determinants of the semantic transparency of mobile phone icons as shown by the authors. The authors results prefer the idea of a consistent approach to information design in mobile devices: age-related differences were revealed as less significant beyond non e-literate users generally slower processing times, which is well known in [7, 10]. This in fact was their second goal to determine whether icon design has to meet age specific design requirements. These results conclude that for good comprehension of icons for different age groups, it is preferable to have identical design features. The authors found that icons should be designed visually simple to be easily understood by both e-literate and non e-literate users and should represent concrete information from familiar context.

The authors in [11], suggested that mobile phone icons are either standardized or customized for different age groups, at least with regard to those functions/objects that have become established (e.g. messaging, address book, calls log, mobile internet). Nevertheless, there might not be as much motivation to standardize mobile phone icons as there is in safety applications [12]. In the case that mobile phone icons are not standardized, then users will experience increased variation in performance across different handsets. In that case, previous studies have indicated that if standardization is not possible, then the designers should at least make the icons as learnable as possible. The authors have found that, in absolute terms, the performance of mobile phone icons is very much problematic for such a popular interaction device. For example, some icons have very low comprehension rates, while some other are obviously irrelevant for anyone who does not have experience with electronic organizers, such as "Palm." Those icons represent high-level abstract concepts (e.g. "Applications") that do not have an obvious real-world metaphor. In addition, the meaning of "calls log" seems hard to depict visually. Firstly, the notion of "calls log" involves a direct reference to fax and ship logs (e.g. a notebook to record dates and events). Then, it seems that both fax and ship logs might not be as familiar as a metaphor should be for wide consumer understanding, because both are profession-specific. In addition, the use of notebook to depict a log might overlap too much with that of the phonebook or the agenda icon. Therefore, the "calls log" icon seems like a good candidate for redesigning and further evaluation of alternatives. Notably, this issue holds true regardless of age group, which was the main scope of their study.

The authors in [13] have addressed with the recognition and representation of icon, still their results can add to the enhancement in how a larger set of user's experience interfaces. However, other issues, such as the color combinations employed in icons and structure of menus, also require a thorough investigation. Since the amount of information in our lives continues to increase, hence the authors stated that as much as possible, information designers must design solutions that match users' requirements. One way to optimize communication with users is to properly select the graphical elements but it will eventually require the awareness of how users interact with graphical elements by the designers. The authors included 54 icons in their study and their results related to functions suggest 6 advices for future research on the workings of icons and icon design practices:

1) Combinations of graphics that are complex or ambiguous decrease the ease with which the icon is correctly interpreted.

2) The use of familiar metaphors increases the likelihood that an icon will be interpreted correctly.

3) Users experience difficulty in correctly interpreting icons that employ symbolic or abstract representations.

4) The users frequently interpreted correctly the Icons with concrete imagery.

5) To interpret the functions conveyed by icons users draw upon their experience of the real world.

6) The scale of the screen size on which the icon is displayed influences how far the user correctly interprets the icon.

3. Methodology

This article measures the recognition level of icons among e-literate and non-e-literate people. The recognition level is further defined as what type of icons they prefer and interpret correctly. We define type of icons on the basis of certain characteristics which make them usable and these are considered before designing any icons. These characteristics are Concreteness, Semantic distance (far, close), Familiarity (very familiar and very unfamiliar) [1].

E-literate means one would be able to read and write by using new electronic medium like internet and mobile technology. In today's 'Information Age', if you are not e-literate, you will be considered as illiterate!

Non E-literate means one would not have access or possess any technological gadget but somewhere has seen it or have a little experience with it

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Concreteness: Concrete symbols tend to be more visually obvious because they depict objects, places, and people that we are already familiar with in the real world.

Semantic distance: Semantic, or articulatory, distance is a measure of the closeness of the relationship between the symbol and what it is intended to represent. In some cases the relationship is very clear. Like printer

Familiarity: Familiarity reflects the frequency with which symbols are encountered.

In other words we can say the purpose of this study is to investigate the effects of icon characteristics such as Concreteness, Semantic Distance and Familiarity on recognition level of icons among E-Literate and Non E-Literate people.

This work has been carried out in two steps:

Step 1: There is no straightforward way or standard mechanism to quantify the Concreteness, Semantic Distance and Familiarity of an icon. To avoid biasness in assigning values to these characteristics we are going to conduct separate research. The purpose of this research is to assign weights of Concreteness, Semantic Distance and Familiarity to each icon.
Respondents of this research are selected on convenient basis. These respondents will be experts of field and critical thinker. To get an appropriate level of accuracy we have selected 15-20 experts.

For data collection an instrument is designed (present in Appendix). This instrument contains 12 sets of icons having different functionalities and each set contain 5 different icons. The icons which are selected for this instruments represents major functions of cell phone [2][3][4][5]. The experts have to rank each icon from 1-5 on the basis of three characteristics (Concreteness, Semantic distance, Familiarity)

Then the Ranking scale will be used to get Mp, Zj, Rj value of each icon, from responses of Experts and a numerical value will be assigned to each icon.

Step 2: In this step we selected 380 respondents from Sukkur and Ghotki city. The instrument which we have designed to get data is online questionnaire which contain different icons of different functions. The enumerators will be selected to get response. At last the result of this research will suggest what percent of concreteness, semantic distance, and familiarity an ideal icon should possess. The details are in the following sections:

Sampling or Census
The development of technology has also increased its usage. There are 129 Million users of cell phone in Pakistan [6]. Their usage and understanding level differ from each other as a result of age and knowledge about technology. For getting accurate results it is best to ask each of them how they perceive different icons on this basis of their knowledge. But this requires resources such as time, cost for travelling to each person and take response and material etc., which is quite difficult to manage. As we have limited research scope so, we will go for sampling.

Sampling Technique:
In below sections the sample design of our research is defined:

Type of Universe: The universe of my work is finite because we will study only e-literate and non e-literate people. It seems possible to find the number of e-literate and non e-literate people of any age in any city, so it becomes finite.

Sampling Unit: Sampling unit for our research is geographical because samples will be selected from two cities of Sindh i-e Sukkur and Ghotki.

Size of Sample: The literate population of Sukkur is approximately 636,237 (46% of total population 335,551 because Pakistan's literacy rate is 46%). If we select 5% of this population on convenience basis then we have to select 31,811 respondents. The literate population of Ghotki is approximately 92,000 (46% of total population 200,000 because Pakistan's literacy rate is 46%). if we select 5% of this population on convenience basis then we have to select 4,600 persons. From these results now we have population of 36,411 as a whole to take response. As mentioned earlier we will do sampling from whole population, now we have to calculate sample size from these figures. According to online sample size calculator [7] we would select sample size of 380 respondents from 36,411 with 95% accuracy of results and 5% margin of error. From 380 respondents 190 will be selected from Sukkur City and 190 will be selected from Ghotki. Distribution of E-literate and non e-literate will be equal in both cities means 95 E-literate and 95 non e-literate from each city.

Parameters of Interest: Parameters of interest which we want to study about respondents are their understanding level of technology on basis of icons recognition and age related difference in usability of mobile phones.

Budgetary Constraints: Very limited time and even more limited Budget.

Sampling Procedure:
There are basically two types of sample designs i-e probability sampling and non-probability sampling. In probability sampling each item of universe has equal opportunity to be included in sample. On the other hand in non-probability sampling the item are selected purposely by researcher.
Considering the limitations discussed above, we would prefer non probability sampling. In non-probability sampling there are three subtypes i-e Purposive Sampling, Convenience Sampling and Quota Sampling. From them we will use Quota Sampling.

To get responses from two different cities we need people who will work as enumerators. Their responsibility includes getting responses from their family or nearby people with division of E-literate and non e-literate respondents and some defined quota will be given to them. Therefore, the way of our sampling matches with Quota Sampling, which states 'Under this technique the interviewers are simply given quotas to be filled from different strata, with some restrictions on how they are to be filled and the actual selection of item for sample is left to the enumerator's discretion'. This technique is also very convenient and inexpensive.

Scaling Technique & Scoring:
There are basically five types of scaling techniques. Each has pros and cons but still depends on purpose of investigation. The most suitable to this study is Item Analysis Approach (Likert Scale).

We prefer Item Analysis Approach over Arbitrary approach to avoid biasness and get the most accurate results. We are not getting response from judges so we can't use Consensus approach. Although for instrument defined in step 1 we are applying consensus because they will be filled by experts. Based on expert's response, we will assign value to each icon and if any icon or set of icon get very diverse results that will be excluded from questionnaire. If we don't exclude then this will also confuse respondents in actual data collection. Factor analysis approach is discarded because we are not measuring multi-dimensions of any single object and to some extent it is difficult to use.

Item Analysis scale is much appropriate because it seems to be used when we have to express agreement or disagreement attitude towards the given object. In our case we have to check which one icon from set of five icons is preferred (liked) by respondents.

Every time an icon is selected it will get score of 1. After getting response from all respondents the frequency of selection of each icon will be calculated. The procedure is as follows:

1. Frequency of most selected icon from set of 5 icons will be observed. This will be performed for each set.

2. Characteristics of selected icon from each set will be observed.

3. After observation of all selected icon's characteristics a comparative analysis within different icons will be carried out to find out similarity and dissimilarity among them.

4. At last the common characteristics of most selected icons will be identified that informs how an ideal icon should be, which become suitable for all types of user.

There were 20 sets of icons of different functionality in initial instrument. After reviewing literature [2][3][4][5] and consensus this reduced to 12 sets. These icons represent the basic functionalities which an ordinary cell phone should possess. The analysis which will be performed in step 1 will also identify any diverse and confusing sets, so, we can exclude them on basis of some score. These will not be included in instrument used in step 2.

Data Collection Method:
For data collection an instrument is designed, i.e., online questionnaire. It contains 12 sets of icons having different functionalities and each set contain 5 different icons. The icons which are selected for this instruments represents major functions of cell phone [2][3][4][5]. This is same instrument used in step 1. The differences are:

• This is online and that was paper based.

• In step 1 instrument, experts have to rank each icon while in this respondents will select one icon from each set on basis of functionality defined.

The respondents of this research are e-literates and non e-literates with no any age limit. As my instrument is not paper based so the non e-literates will become unable to respond which are major source of data. To consider this we have chosen 'Data collection through Schedules' method. In order to make the data collection process convenient and accurate the enumerators will be selected based on the district they belongs to, i.e. resident of Ghotki will be selected to collect the data in Ghotki city and resident of Sukkur will be selected to collect the data in Sukkur city district . An orientation session will be given to all the enumerators, where they will be briefed about the purpose of the study and how to collect data from respondents. The selection of respondents is upon discretion of enumerators, they will be assigned quota for number of respondents.

We prefer this method because this was much suitable to the research proposed in this study. We can't use observation method because it is unable to observe the respondent how he selects certain icon in mobile phone than other. Interview method is also not appropriate because of cost and time and it is infeasible to ask about icon interpretation in interview as this requires the presentation of icon to respondent. Questionnaire is best technique to use but as stated earlier half of the respondents are non e-literate, getting a direct online questionnaire will make them confuse. With these reasons the enumerator will be selected which make them understand the questions and get proper response. With this technique a large area can be covered too.

4. Analysis And Results

Step 1 Questionnaire Analysis:
The respondents were asked to rank (1-5) each icon on the basis of three characteristics. Total 10 responses were collected. The mean concreteness, semantic distance and familiarity were calculated for each icon in Excel. Further, concreteness was divided into two groups' i-e concrete and abstract. The icon with mean value greater than 2.5 was considered as concrete while icon with mean value equal or less than 2.5 was considered as abstract. Also semantic distance was divided into two groups' i-e near and far. The icon with mean value greater than 2.5 was considered as semantically near while icon with mean value equal or less than 2.5 was considered as semantically far. Familiarity was divided into two groups' i-e high and low. The icon with mean value greater than 2.5 was considered as more very familiar while icon with mean value equal or less than 2.5 was considered as less familiar.

Step 2 Questionnaire Analysis:
In this questionnaire the respondents were asked to select most appropriate icon from a set of 5 icons according to functionality. Along with icon they have to enter their age, city and mobile phone information (do they have mobile or not). The data was being saved in spreadsheet in google drive.

SPSS 18 was used to analyse the data. Records of E-literate and Non E-literate were separated in spreadsheet on the basis of mobile phone information. Then selection frequency of each icon was calculated by defining a macro in excel for both E-literates and Non E-literates. On the basis of highest selection frequency, one icon was selected from each set. This gives total of 10 icons of 10 different mobile phone functions. Then recognition rate was calculated for each icon and Independent sample t-test was performed to check if E-literates and Non E-literates have same Recognition rate for icons.

Hypothesis: Effect of Icon Concreteness, Semantic Distance and Familiarity on recognition level of mobile phone icons among E-literate and Non E-literates.

Independent variables: Concreteness (Concrete, Abstract), Semantic Distance (Near, Far) and Familiarity (High, Low)

Dependent Variable: Recognition Rate of icons

Hypothesis is being tested by breaking down the original hypothesis into two separate hypotheses. In first hypothesis E-literate is between subject variable where subject refers to respondents. In second hypothesis concreteness, sematic distance and familiarity are between subject variables where subject refer to icons.

1. Ho: E-literate and Non E-literate users have same recognition level of icons.

Ha: Recognition level of icon differ among E-literate and Non E-literate users.

2. Ho: Recognition rate of icon doesn't depend upon icon concreteness, semantic distance and familiarity.

Ha: Recognition rate of icon depends upon icon concreteness, semantic distance and familiarity.

Proof of Hypothesis 1:

Ho: E-literate and Non E-literate users have same recognition level of icons.

Ha: Recognition level of icon differ among E-literate and Non E-literate users.

In this hypothesis there is one dependent (recognition level) and one independent (E-literate) variable. Further independent variable is divided into two group's i-e E-literate and Non E-literate.

Setup of Data for Analysis:

1. Recognition rate of each icon was calculated for both E-literates and Non E-literates. Recognition Rate (%) = Number of Responses/Total Number of Reponses *100

2. Ten icons were selected (B5, C3, D1, K1, L3, N5, P1, R3, S3, T3) one form each set, on the basis of highest recognition rate.

3. Step 2 was performed separately for both E-literates and Non E-literates.

Figure 1, shows the recognition rate of E-literate v/s non E-literate respondents.

We have used Independent t-test to prove this hypothesis because this test compares the means between two unrelated groups on the same continuous, dependent variable. This test has been performed in SPSS 18.

The independent t – test makes 6 assumptions about the data. Below is description of each assumption and how we have handled it.

Assumption #1: Your dependent variable should be measured on a continuous scale. Our independent variable (recognition rate) is already in ratio form.

Assumption#2: Your independent variable should consist of two categorical, independent groups. In our case categorical variable is E-literate and it consists of two independent group's i-e E-literate and Non E-literate.

Assumption #3: You should have independence of observations. No nay participant was included in both groups.

Assumption #4: There should be no significant outliers. Presence of outliers was verified through box plot.
Figure 2, shows that there is no any value outside the mean recognition rate for e-literate and non e-literate it means there are no outliers
.
Assumption #5: Your dependent variable should be approximately normally distributed for each group of the independent variable. Normality of data is checked through **Shapiro-Wilk and Kolmogorov-Smirnov** test, as shown in Table 1.

	Eliterate	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
RecognitionRate	No	0.157	10	.200*	0.939	10	0.545
	yes	0.174	10	.200*	0.916	10	0.326

Table 1. Test of Normality

For the independent t-test if the sig (2 tailed) value is *equal or less* than .05 there is a significant difference in the mean scores on your dependent variable for each of the two groups. In table 3 the sig value in 0.000 which is less than 0.05 which mean there is different recognition rate among E-literate and Non E-literate. We can also see that mean recognition rate of E-literate is 75.9 while mean for recognition rate of Non E-literate is 57.5; there is appropriate mean difference between two groups. So, we can reject the null hypothesis which states the recognition rate is same for both groups.

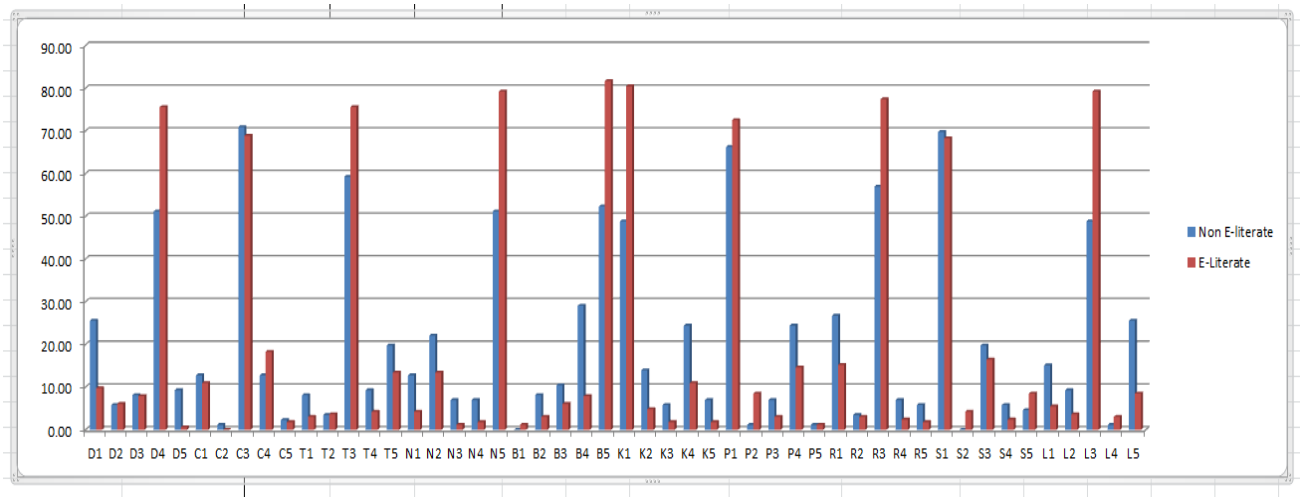

Figure 1. Bar chart for Recognition rate of E-literate v/s non E-literate

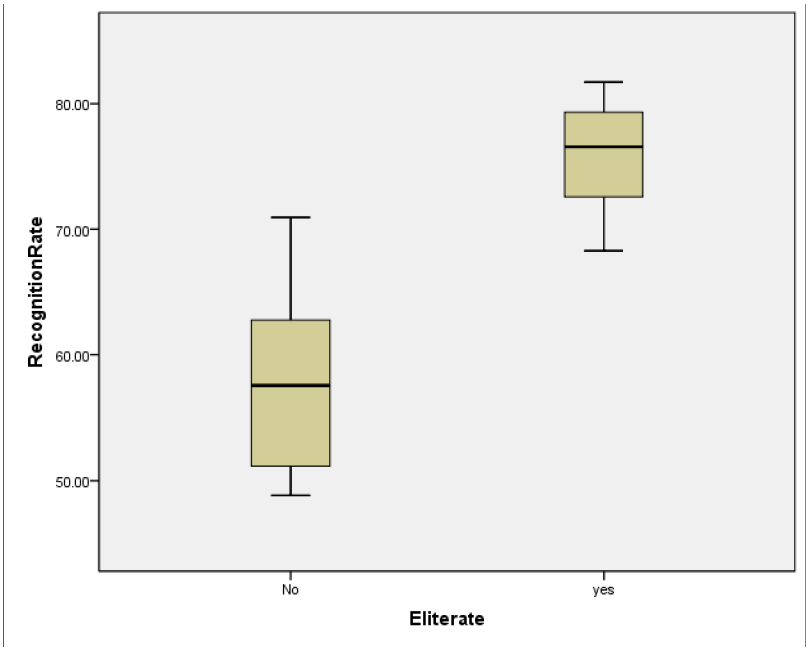

Figure 2. Boxplot for outlier detection

Proof of Hypothesis 2:

Ho: Recognition rate of icon doesn't depend upon icon concreteness, semantic distance and familiarity.

Ha: Recognition rate of icon depends upon icon concreteness, semantic distance and familiarity.

This hypothesis suggests that if we increase the concreteness, sematic or familiarity of icon the recognition rate will also be increased. In this hypothesis there is one dependent and three independent variables. First we have analysed if there is any relation among three independent variables. For this reason, we have calculated the mean of concreteness, sematic and familiarity for each icon (50 icons). The mean shows that if any icon has highest concreteness it's semantic and familiarity ratios are also highest. The icon c1 has 3.7, 3.8, 3.7 mean concreteness, sematic and familiarity and icon c5 has 1.64, 1.82, 1.64 mean concreteness, sematic and familiarity. Further correlation between independent variables is shown in table 4.

	Concreteness	Sematic distance	Familarity
Concreteness	1	0.9	0.6
Sematic distance	0.9	1	0.7
Familarity	0.6	0.7	1

Table 2. Correlation among concreteness, Semantic Distance and Familiarity

In Table 2, correlations is greater than 0.5 for each combination of characteristics so we can say that independent variables are positively correlated.

The hypothesis has one dependent (recognition rate) and three independent variables (concreteness, semantic, familiarity) variables. Further each independent variable is divided into two groups: Concreteness (Abstract, Concrete), Sematic distance (Near, Far), Familiarity (High, Low)

5. Conclusion

This paper looked at the cell phone which is one of the technologies widely used in developing countries. Many people can afford to have cell phones but experience difficulties in making full use of them, such that they only operate the basic functions. One of the reasons for this is the low comprehension level of icons being used in the interface. This article explores the effect of icon characteristic on recognition level of icons among e-literate and non e-literates users.

Quantitative methods were used to analyses the results. An online questionnaire which contains 10 sets of icons (representing major functionalities) of a cell phone (total 50 icons, 5 in each set) was filled by 250 respondents. There were 164 E-literates and 86 non E-literates respondents. The Recognition rate for each icon was calculated and one icon from each set was selected on the basis of highest selection frequency. Independent sample t-test was performed to see if e-literates and non e-literates have same recognition level. As significance value of this test was 0.000 which is less than 0.05 so we conclude that e-literates and non e-literates perceive the icons differently.

Further, we performed Three Way Anova to check if icon concreteness, semantic distance and familiarity have effect on icon recognition rate. The sig value of Three Way Anova was 0.03 which is less than 0.05. This means there is interaction effect of three characteristics on recognition rate. Concreteness and Familiarity with the sig value of 0.126 and 0.847 respectively don't cause the individual effect on recognition rate of icon while semantic distance with sig value of 0.013 do effect recognition rate. As a result, we can say if an icon is represented by more real life metaphors, which portrays the functionality and people are familiar with this, then that icon is easily interpreted by any novice or experienced user.

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