Perceived aesthetics of user-modifiable layouts: a comparison between an unspecified design and a GUI

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ABSTRACT
This paper presents the results of an experiment in which students are asked to reposition rectangular shapes in a window in two cases: when they are or they are not told that the window should be considered the configuration of a graphical user interface (GUI). The main aim of the research is to investigate if users have different aesthetical preferences in the two distinct cases. Other goals are to see if, in the case of a GUI, the aesthetical criteria relate to cognitive ergonomics and if there are some preferred shape patterns.

Author Keywords
Beauty measures; aesthetics; human-computer interfaces design; cognitive ergonomics

ACM Classification Keywords
H.5.2 User Interfaces: Graphical user interfaces (GUI).

INTRODUCTION
The omnipresence of computer-based devices such as smart phones, tablets, laptops and the large amount of time spent by people interacting with them obviously show the importance of paying a major attention to the design of their human-computer interfaces. In this direction, user models and cognitive ergonomics rules are considered in the Computer-Human Interaction (CHI).

However, one important human factor gets considerable less attention in the design of human-computer interfaces: aesthetics. People buy various fancy cases for their phones, upload or even buy nice backgrounds for their laptops or ringtones for the phones. Therefore, it is obvious that users seek aesthetical features of their devices. Even if "beauty is in the eye of the beholder", several general aesthetic principles may be identified, such as symmetry or harmony of colors.

There are also mathematical formulas in aesthetics, the most well-known being the golden ration or the ratios of nice sounding musical chords remarked by Pythagoras. In addition to these, we can mention George David Birkhoff's "measures of beauty" [1], Matila Ghyka [2-4], and Pius Servien [5], which tried to identify mathematical relations that characterize beauty.

Cognitive ergonomics principles focus on eliminating cognitive load in using interfaces to computers, which means easing the understanding of their functionality and the finding of needed controls. Some of these principles, even if they are not explicitly linked to aesthetics, they are in consonance with them. For example, the grouping principle, which states that similar controls should be grouped, for example, that a series of check-boxes should be put on vertical or horizontal line, at equal distances, is in consonance to aesthetic principles of order, harmony or symmetry.

In CHI there were researches to identify measures or rules for assuring aesthetics of the Graphical Users Interfaces (GUIs) [6-13]. Some of them included experiments in which users were asked to grade the aesthetics features of interfaces [8, 11, 13]. Our approach introduces a new idea: to analyze how users would rearrange a set of GUI components in order to be both esthetical and usable. The considered research questions were: 1) do users have different aesthetical preferences in the distribution of shapes in the case of an unspecified image and a GUI? 2) Might some patterns of arranging shapes be identified? Consequently, an experiment was performed in which several groups of computer science students were put to rearrange a set of interface elements shapes and the results were analyzed according to several aesthetical criteria.

This paper presents in the next section an overview of the proposed mathematical relations for "measuring" beauty, and some researches in the analysis of the relations between the design of GUIs and aesthetics. The third section presents our experiment and associated discussions. The paper is completed by conclusions.

RELATED WORK

The mathematics of beauty
There were several approaches during history to identify mathematical formulae of nice looking shapes or pleasant to listen groups of sounds. Probably the most well-known mathematical measure of beauty is the golden section (or ratio), which was used for many artists. This ratio is related directly with Fibonacci numbers, which, in fact, both represent a natural law of growth, they may be found in many places in nature, for example in flower petals,

spiral galaxies, snail shells' logarithmic spiral, etc. [14]. An extensive analyze of the presence of the golden ration throughout history was made by Matila Ghyka [2]. Maybe the fact that we consider beautiful shapes following the golden ratio might be explained exactly by its omnipresence in nature. Other approaches to analyze mathematical or physical properties of beautiful things were proposed by the same Matila Ghyka [3, 4] and by Pius Servien [5].

George David Birkhoff had important contributions in mathematics but he also investigated aesthetics, introducing a "measure of beauty". Birkhoff considered that beauty is directly proportional with order or organization (O) and inverse proportional with complexity (C) [1]:

$$\mathbf{M = O / C}$$

In other words, we may say that Birkhoff considered beautiful something simple and with an ordered/organized structure. He also gave metrics to various polygonal shapes, according to the above formula.

Measurements of aesthetics in Human Computer Interaction

The idea to analyze graphical user interfaces aesthetic features using metrics and other criteria was considered by a series of researchers [6-13]. Some approaches classify visual techniques, visual complexity elements or features that may be used for placing interface components [6, 10, 13]. For example, Vanderdonkt and Gillo identify five groups of visual techniques [6], from which we mention: *Physical* (balance, symmetry, regularity, alignment, proportion, and horizontality), *Composition* (simplicity, economy, etc.), *Association and dissociation* (unity, repartition, grouping, and sparing), *Ordering* (consistency, predictability, sequentiality, and continuity), and *Photographic* (sharpness, roundness, etc.).

Buanga identified a series of factors to be taken into account when analyzing graphical user interfaces, some of them being [10]: Visual balance (in vertical or horizontal axis), Proportion, Repetition, Rhythm, and Unity. Zain et al. consider Balance, equilibrium, symmetry, sequence, rhythm, order and complexity [11].

Many approaches use questionnaires for getting an image on the users' perception of the aesthetics of the interfaces [8, 11, 13]. These questionnaires are usually analyzed with statistical tools.

Mathematical formulae were proposed for various metrics for the analysis of the aesthetics of interfaces [7,9-12]. Some approaches developed software applications for evaluating the quality of existing interfaces (for example, the Web-based evaluator tool QUESTIM (Quality Estimator using Metrics) [9]) or Aesthetic Measurement Application (AMA) [11].

As a result of the performed research, some approaches propose design rules for arranging GUI components [6, 10].

THE EXPERIMENT

The research started from an inquiry about how people prefer to organize a set of shapes in a computer desktop window. One hypothesis from which we started was that people have different aesthetical preferences in the distribution of shapes in the case of an unspecified image and a graphical user interfaces. Another hypothesis was that people prefer some particular arranging, like rhythm, phenomenon more remarked in music and poetry [15].

The experiment consisted in assigning to several groups of students a homework in which they had to run a Java application which displayed a set of rectangles in a window (see Figure 1 for the initial configuration, common for all the groups) and they should rearrange them in a configuration that they consider aesthetical. A part of them were told from the beginning that the shapes in the window are elements of a GUI. A second part had to repeat the assignment and only in the second step they were told that they should think to a GUI configuration.

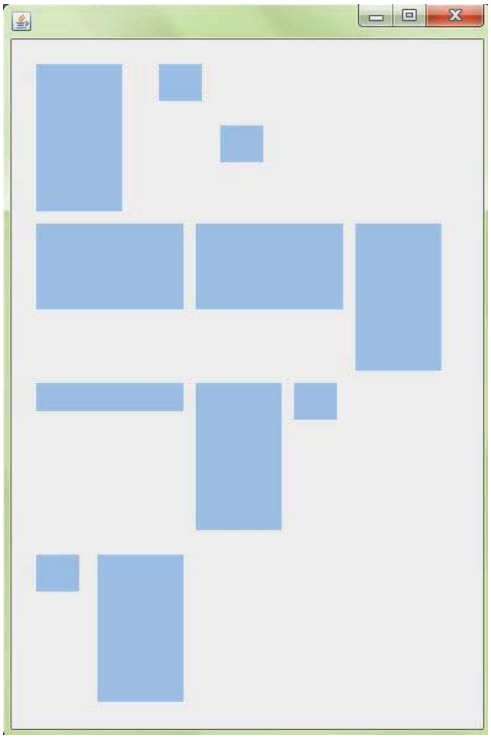

Figure 1. The initial configuration of the shapes to be moved.

Four groups of computer science students were involved in the experiment:

1) 13 master students in Artificial Intelligence,

2) 17 master students following an advance database systems course in master,

3) 11 sophomore students,

4) 34 students of a semantic web master course.

The first three groups were from the Automatic Systems and Computer Science Faculty of the University Politehnica of Bucharest and the latter from the Faculty of Engineering in Foreign Languages from the same university. The first three groups were of Romanian nationality and the fourth had Romanian, Arabic, and

other European nationalities (Austrian, Serbian, etc.), therefore different cultural traditions were covered.

We will present first the results of the analysis of the 4th group. The experiment with this group had two steps. Students received a java program that displays an initial arrangement of rectangles (see Figure 1) and squares and allows them to rearrange them. The program generates an output file that students had to send by email to the professor.

In the first step, students received the following indications:

The program displays a window with several rectangles. Your task is to move the rectangles in such a way that the whole arrangement looks most pleasing to you, aesthetically. You must arrange the rectangles so that all the rectangles are displayed and no rectangle overlaps with another. If needed, you may increase the size of the window.

After the deadline of a week, students got the indications for the second step, in which they were announced to reconsider the arrangement they made in the first step, this time taking into account that the shapes are of a graphical user interface:

Re-run the RECTANGLES task, but now considering that the rectangles are: 6 windows, one text area (the long, slim rectangle), and 4 check boxes (the four small rectangles) in a Graphical User Interface (GUI). You should arrange them to be as nice looking as possible, but also easy to use as a GUI.

We have manually evaluated comparatively the arrangements of the shapes made by students in the two steps according to the following features, giving grades from 0 to 10 (the standard grades in schools and universities in Romania; 10 is the best):

- vertical symmetry;
- horizontal symmetry;
- repetitions (sequences) of shapes;
- figurativity (some students arranged the shapes in a figurative way – see, for example, Figure 2);
- rhythm breaking.

The results were that vertical symmetry average grade changed from 6.647 to 6.76, horizontal symmetry from 3.441 to 4.2, sequencing from 4.529 to 9.821, figurativity from 7.5 to 5.5.

We see that the changes of averages due to considering that the shapes are parts of a graphical user interface were mainly on the considerable increase of sequencing, a moderate increase of horizontal symmetry and decrease of figurativity.

These results are not surprising. The decrease of figurativity shows probably that users prefer an interface more directed to usability, without being a figurative image. The increase of sequencing is also probably related to a need of a more ordered configuration of shapes, fact also recommended by the cognitive ergonomics grouping principle.

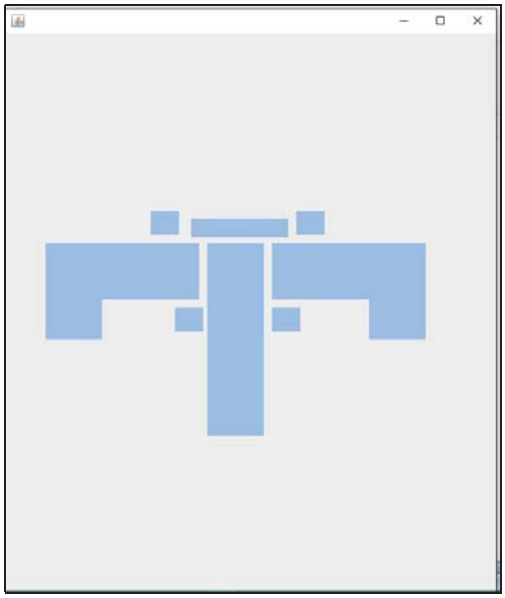

Figure 2. First step - a figurative image.

A comparison of these results with those of the first group of students is interesting because for the latter there was a single step. They were announced from the beginning that they should arrange the rectangles as for a graphical user interface:

The program displays a window with several rectangles. Your task is to move the rectangles in such a way that the whole arrangement **looks most pleasing to you, aesthetically**. You must arrange the rectangles so that all the rectangles are displayed and **no rectangle overlaps with another, and there is even a small space between them**. If needed, you may increase the size of the window.

You should also consider that **the rectangles are shapes in a Graphical User Interface (GUI)**: 6 windows, one text area (the long, slim rectangle), and 4 check boxes (the four small rectangles). You should arrange them to be as nice looking as possible, but also easy to use as a GUI.

The results were very similar to the second step of the fourth group (vertical symmetry average grade 6.75; sequencing 9.167), excepting horizontal symmetry, which had an average of 1.5.

CONCLUSIONS AND FUTURE WORK

The experiment presented in the paper is a first step in a series in which we want to analyze the relation between users' preferences on aesthetics and usability in GUIs. A clear difference was remarked between the cases when students were or were not told that the configuration they consider as aesthetical should be of a GUI. In the second case, for example, many of them rearranged the rectangles in a figurative configuration, which was no more the case in the first case, when they preferred a sequential organization to a figurative configuration. This result is consonance to cognitive ergonomics principle of grouping. As a consequence of the above considerations

we may conclude that both our research questions have positive answers.

The results will be further analyzed, including more elaborated statistical tools and other evaluators. More experiments will be performed, including also other domains, for example texts and also automated tools [9, 11].

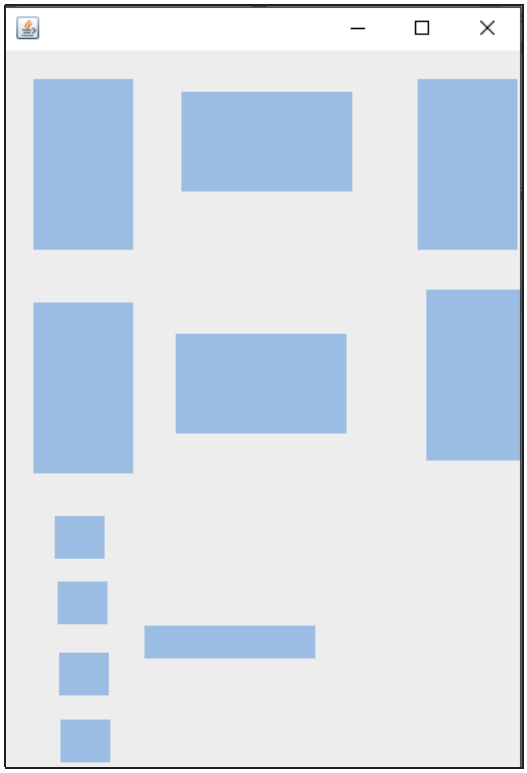

Figure 3. Second step of the same student from Figure 2 - a non figurative, interface-like shape.

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