

## GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES DATA VISUALIZATION AND VISUAL PERCEPTION

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### ABSTRACT

Nowadays, data is growing at a tremendous scale and to understand this data in a better and easy way, the role for data visualization is crucial. It represents the textual information in a graphical or pictorial form which helps in conveying essential information to the managers and business persons. But different creatures of the earth see things differently and therefore form different perceptions. This paper elaborates the significance of visual perception in visualizing data with the help of Gestalt principles. Apart from this, some new factors in visual perception of multi-dimensional data are also discussed.

**Keywords:** *Data Visualization, Gestalt Principles, Visual Perception, multi-dimensional data.*

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### I. INTRODUCTION

Today the quantity of data is growing at an incredible rate and the ability to collect and store the data is continuously increasing than the ability to analyze it [1]. Due to the complex nature of many problems, data visualization becomes important for analyzing the data. Data Visualization is a graphical representation of a large amount of complex data that is used for a better understanding of data as it is also said that the picture is worth a thousand words. In data visualization, visual perception plays an important role. The quality and quantity of data that is being delivered can be improved significantly with the concept of visual perception [2].

Visual Perception can be described as the way the brain interprets what surrounds us or it may be called the end product of vision. The brain receives information from the retina and then using different hierarchical methods, go through the complex parts of the brain to process the information. Now, visual perception becomes an essential part of data visualization because the things or images are seen by the human brain is not a direct translation of these things, which makes it difficult for a human to understand which things to see and which things not to see. It means it cannot be judged that what we see. So this visual perception sometimes can also mislead people, therefore we have to take care of Gestalt Principles which are based on the idea that how the human brain will try to interpret things. In data visualization, we also have to take care of graphical elements (points, lines, surfaces) and graphical properties such as size, texture, orientation, color, etc. Cleveland and McGill said in their theory of graphical perception that some graphical properties are more important than others like their experiment where they notice color saturation has a high number of errors make it less accurate and position aligned things contain least error makes it more accurate [3].

The main purpose of data visualization is to help in good decision making [4]. It is important to understand trends, patterns, and relationships from the visualizations to make good decisions. This can also be considered as discovering knowledge from data or drawing insights from data. But the tricky thing is that the image seen by the human eyes is not the same as is it seen or interpreted by human brains. Humans try to see the things which are eye-catchy and the things with which he is familiar with. That is the human brain pays attention to selective things and familiar patterns. Also, the memory of human hold a limited amount of information by looking at objects or images as the working memory of human is limited.

Data visualization is considered effective because to take full advantage of the abilities of the brain, the balance between perception and cognition is shifted by it [5]. Visual Perception means the things which are seen

immediately by the visual cortex, with little effort, and is extremely fast and efficient. Cognition means thinking which is done by the cerebral cortex in the brain and is much slower and less efficient. In the visualization domain, human perception plays a great role as it supports the cognitive associative process [6].

**II. VISUAL PERCEPTION**

The different creatures see the world differently; that is one’s perception of seeing is different from others. For instance, animals also see the world in different ways; like a human can see the television where it runs 25 frames per second but it is very slow for flies. Similarly, octopuses dedicate their 50% of the brain for only seeing. The field of vision of hare is 360 while a human can see in the vision of 160 to 240 [7]. So, we as humans do not see the full truth of visual perception. Therefore, what one person sees can be very different from another person’s vision or perception.

Researchers studied that people see according to their comfort and wishes [8]. For example, many people see ‘B’ as English alphabet B while others may see it as numerical number 13. So how the human react to things or objects depends upon its thoughts, feelings, and consciousness. As the visual perception affects the humans so it also has a straightforward effect on data visualization, otherwise visualizations that are meant for better understanding can mislead the people also. It depends on the human brain that how one interprets the geometrical shapes and its relations [9]. For instance, simple data of four fruits and their number is shown in Figure 1. Data is represented in a 3D graph using excel. But it seems like the values shown on the graph differs from the original values in the cells. So using an area for just representing fruits and its quantity makes the observations look larger than they are.

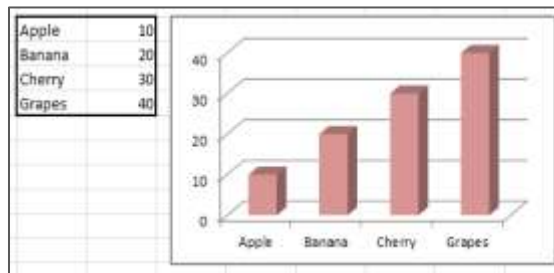


Fig 1: 3D bar chart in Excel

**III. GESTALT PRINCIPLES**

Gestalt theory is based on the idea that how the human brain will try to interpret things. It explains how humans make sense of objects [10]. It helps the designers to produce good symmetry in design and to achieve better visual hierarchy. The human brain wants to group similar things. The subconscious mind will try to find patterns and structures in the things to understand things in a better way.

**1. Similarity**

This principle states that the human brain will try to group similar things together. For instance, in figure 2, the human brain will group the boxes with the same color.

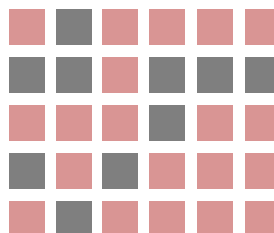


Fig 2: Similarity

Hue and Saturation are good if used for categorical things but not for representing quantitative data [11]. If we are talking about just one group then in visualization, it should be kept with the same color as shown in figure 3(a), and the number of group with different colors as shown in figure 3(b).

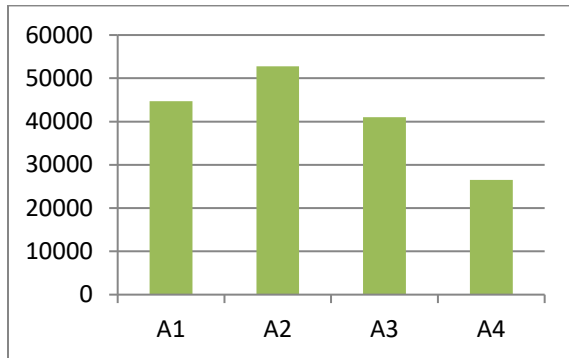


Fig 3(a): Bar chart with one group

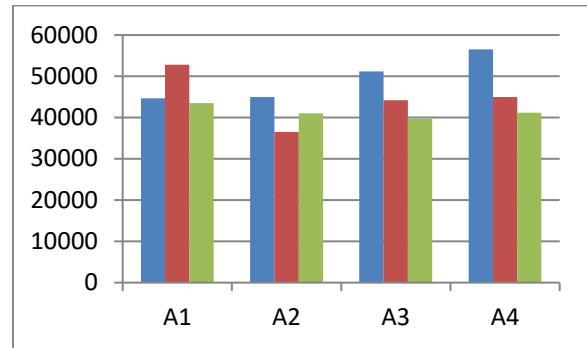


Fig 3(b): Bar chart with multiple groups

## 2. Proximity

This principle is based on how close things are with each other. The things which look closer human brain saw it as a group. For example, in figure 4 two groups can be seen, left with 10 small boxes and on right with 20 small boxes.

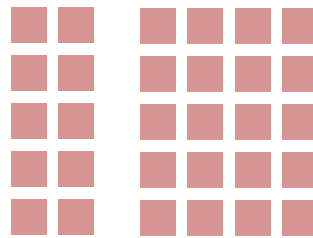


Fig 4: Proximity

In the bar chart that is shown in figure 5, there are three different things but due to its closeness, it seems to like in one group.

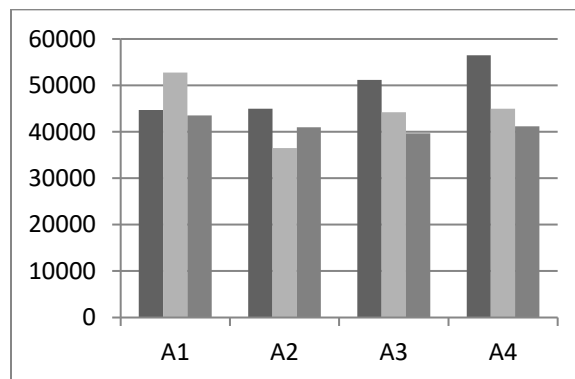


Fig 5: Bar chart showing proximity behavior

## 3. Closure

This principle states that the human brain will draw the dotted lines the missing portion of the image to see the image as a whole. This can be seen in many logos like the World Wildlife Fund (WWF), Adobe, Adidas, IBM. For

example, in figure 6 it looks like there is a square in between the four circles, but it may be the four-quarter circles drawn.

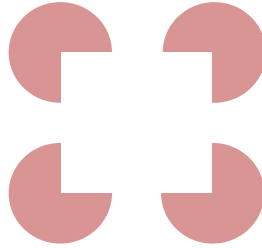


Fig 6: Closure

In the line graph shown in figure 7, some data is not known but the human mind will automatically generate a dotted line in mind and complete the shape.

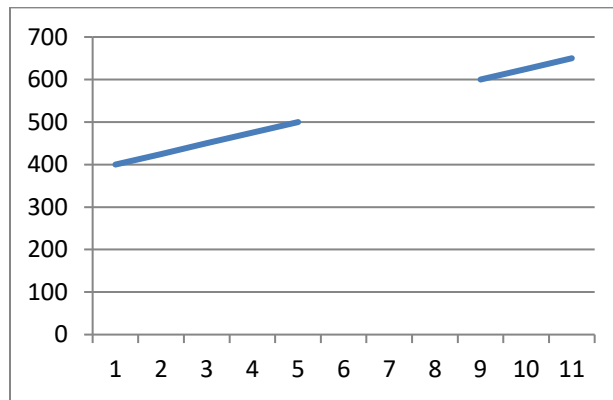


Fig 7: Bar chart showing closure principle

#### 4. Continuity

This principle tells that the human brain attempt to see things in continuity. The things which are aligned with each other, we try to group them [12]. For example, in figure 8, it seems like a cross is made but it may be two V's drawn opposite to each other.

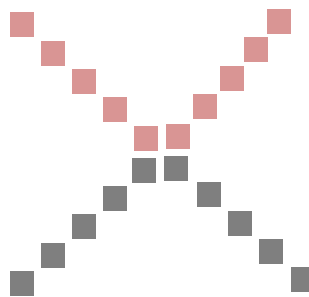


Fig 8: Continuity

In the bar chart also, it is like continuously decreasing something as shown in figure 9. So using this law we have found some patterns in the graph.

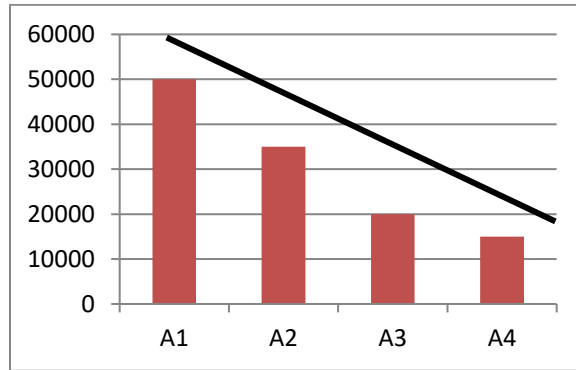


Fig 9: Bar chart showing continuity in value

### 5. Symmetry

This principle states that the human brain loves to see symmetry, simplicity, and order in things. It is also called Pragnanz [6] which is a German word for “good figure”. In figure 10, the monochrome logo of the Olympics seems like 5 circles are overlapping each other but it might be the number of arcs drawn.

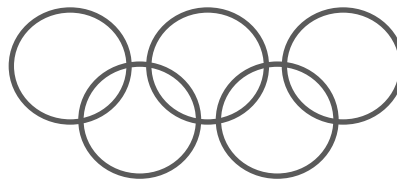


Fig 10: Symmetry

In figure 11(a), the bar chart is unordered; sometimes it is possible to make symmetry in graphs like in figure 11(b), the bar chart shows some dropdown in the graph.

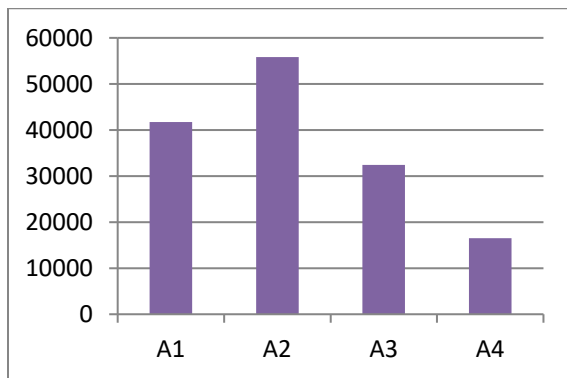


Fig 11(a): Bar chart is unordered

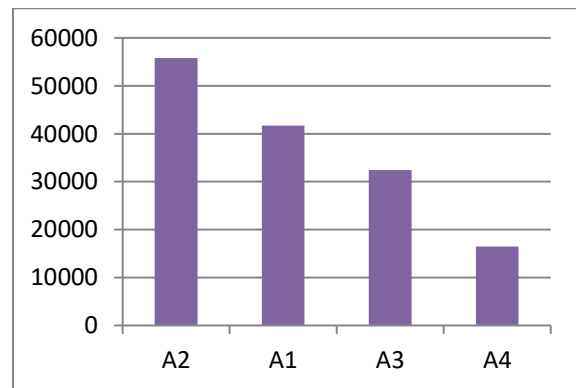


Fig 11(b): Bar chart is ordered

### 6. Figure and ground

The human brain tries to divide the world into two parts, figure and ground where the figure is the thing or object on which we focus and the ground is the background. Like in figure 12, we try to see the ground as a dark color, and light-colored is our figure.

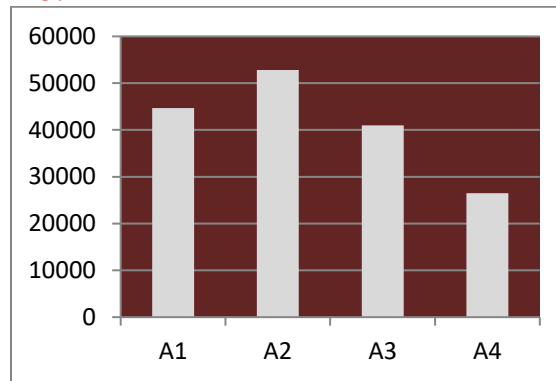


Fig 12: Bar chart showing figure and ground

#### IV. VISUAL PERCEPTION: NEW INSIGHTS

Nowadays, with the increasing human-computer interaction and with the proliferation of work in inter-discipline areas like information visualization, brain exploration, and cognitive psychology, visual perception can be benefited especially from two areas, i.e pre-attentive visual processing and working of human attention and memory, along with its limits. The pre-attentive visual processing is something that comes into our mind before consciously analyzing the visual picture[13]. The expert neurons are used to handle the different stages of this process and information is combined from various stages and form a picture in the head in the end. Another important factor for visual perception is human attention and memory, which can be assisted to retain more information in available memory[14]. Multi-dimensional data can be visualized by presenting its multiple views, which help in analyzing the relations of data from multiple angles, which are not possible otherwise.

#### V. CONCLUSION

In this paper, we have discussed the visual perception and its importance in data visualization. It is important to keep in mind the Gestalt Principle before drawing any visualization. By understanding these principles, designers can make better visualizations, as these principles are the part of visual perception and therefore visual perception has a great role in data visualization. Along with this, pre-attentive visual processing and working of human attention and memory, along with its limits are new insights to the visual perception for better visualization of new emerging multi-dimensional data, although, more research is needed in this area.

#### REFERENCES

1. C. S. Jensen et al., "Visual Analytics," in *Encyclopedia of Database Systems*, Boston, MA: Springer US, 2009, pp. 3341–3346.
2. C. Healey and J. Enns, "Attention and visual memory in visualization and computer graphics," *IEEE Transactions on Visualization and Computer Graphics*, vol. 18, no. 7, pp. 1170–1188, 2012.
3. "Scrolling In Data Visualization." [Online]. Available: [https://rstudio-pubs-static.s3.amazonaws.com/368845\\_9c1cc6de9d984f5688872fadd719c9b4.html](https://rstudio-pubs-static.s3.amazonaws.com/368845_9c1cc6de9d984f5688872fadd719c9b4.html). [Accessed: 29-Mar-2020].
4. "The Role of Visual Perception in Data Visualization." [Online]. Available: <http://daydreamingnumbers.com/blog/visual-perception-data-visualization/>. [Accessed: 24-Mar-2020].
5. "Data Visualization for Human Perception | The Encyclopedia of Human-Computer Interaction, 2nd Ed." [Online]. Available: <https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/data-visualization-for-human-perception>. [Accessed: 25-Mar-2020].
6. D. S. Alexandre and J. M. R. S. Tavares, "Introduction of human perception in visualization," *International Journal of Imaging*, vol. 4, no. 10 A, pp. 60–70, 2010.
7. P. S. N. Majumdar, "Visual perception and Art: A survey across the cultures," IIT Kanpur National Programme on Technology Enhanced Learning (NPTEL).

8. E. Balcetis and D. Dunning, "See what you want to see: Motivational influences on visual perception," *Journal of Personality and Social Psychology*, vol. 91, no. 4, pp. 612–625, 2006.
9. J. F. Tripp, "Data Visualization," in *International Series in Operations Research and Management Science*, vol. 264, 2019, pp. 111–135.
10. W. Craig, "How to Make Data Visualization Better with Gestalt Laws," 2019. [Online]. Available: <https://www.webfx.com/blog/web-design/data-visualization-gestalt-laws/>. [Accessed: 29-Mar-2020].
11. E. Meeks, "Gestalt Principles for Data Visualization: Similarity, Proximity & Enclosure," Github, 2015. [Online]. Available: <https://emeeks.github.io/gestalt-dataviz/section1.html>. [Accessed: 29-Mar-2020].
12. B. White, "Attention, Gestalt Principles, and the Determinacy of Perceptual Content," *Erkenntnis*, no. 0123456789, 2020.
13. C. Schmitt, S. Klingenhoefer, and F. Bremmer, "Preattentive and Predictive Processing of Visual Motion," *Scientific Reports*, vol. 8, no. 1, pp. 1–12, 2018.
14. B. Wortelen, A. Unni, J. W. Rieger, A. Lüdtkke, and J. Osterloh, *Cognitive Info communications, Theory and Applications*, vol. 13. 2019