Visual Design Elements for Data Storytelling Based on Personality Traits: A Case of Undergraduate Students

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Abstract— **Prior studies found a strong correlation between a user's preference for information visualization and the variances in their personality. Visualization software have evolved recently and have given users a number of advantages. Although the usability aspects of visualization software have advanced significantly, they previously adopted a more general approach with their user interface and ignored user variations. There is a dearth of prior study examining user traits and preferred visual data storytelling elements. The use of individual variations as an adaptation metric in visualization tools has shown promise in overcoming the drawbacks of general approach from the user interface of visualization tools. This study intends to investigate into how users' preferences from the various visual design elements for storytelling relate to their personalities among university students in one institution. The study investigates whether personality affects user preferences for various visual design elements such as font type, font size, hierarchical, and comparative visualizations, which are extensively used in contemporary research and are associated with personality. To this end, a personality indicator will be performed to gauge each participant's personality. The participants will next answer a different series of questions on their preferences in visual design elements for data visualization and storytelling. This study may help to address the general issue with visualization tools and may suggest significant implications that may be used in the future design of visualization tools to improve the intuitiveness of the tool to suit various type of users, as well as for the visualization designers by choosing the best graphical visualizations for any given target audience to provide greater comprehension of the information in making critical decisions**

Keywords— Information Visualization; Data Visualization; Data Storytelling; Personality; User-Preferences; Five-Factor Model

I. Introduction

Understanding data through visualization is the same as understanding users, or people. To provide information on how different personalities approach visualization material from their perspective by examining the connections between data visualization and storytelling as well as personality differences, user's personality and their preferences will be the concentrated area of this study. In order to adapt to the new era of information, communication and technology, where knowledge and information were transmitted and conveyed the key factor in achieving sustainable economic growth for every sector of industries, visualization has become essential for educational institutions to introduce this discipline as its core curriculum (Petrovich, 2020). Since the introduction of the digital age, the diffusion of information has been unprecedented. Many organizations have adopted a data-driven strategy and used visualization tools to benefit from the overabundance of available information, but if the target audience has zero understanding toward the chosen visualization, it may resulted in miscommunication and the wrong use of information (Knaflic, 2016). Certain visualizations may have annoying distortions due to color and information layout. Although research on information visualization has a long history, there are couple auspicious work toward the relationship between personality traits and information visualization (Gonc, 2020). This study tries to address the discrepancy between how user personalities may influence their decisions when choosing visual design elements for their information visualization and data storytelling reporting. Finding out how personality and users affect information visualization and storytelling is crucial because it may help visualization tools developers like those behind Microsoft Power BI and Tableau better match their services to the personalities of different types of users. With an understanding of the variations between the user's personality and their preferences with that information visualization and data storytelling, such study may also be useful to both practitioners and researchers in psychology and big data. The results might also allow analysts choose the optimal graphical visualization for a given target audience to provide a better comprehension of the data.

II. RELATED WORK

One of the most popular personality indicators is the Five-Factor Model (FFM). Robert McCrae and Paul Costa created a model that breaks down personality into five main categories (Costa, 2018). Lewis Goldberg, a psychologist, said that FFM is also known as the "Big Five" Personality Factors. He developed the International Personality Item Pool (IPIP), a personality database that describe each attribute. A group of distinct characteristics are related to more intricate features of personality via each of the attribute. As a personality model that has been used in both research and clinical psychology, FFM was selected as the research's personality indicator. The abbreviation OCEAN, which stands for openness, conscientiousness, extraversion, agreeableness, and neuroticism, as well as the three fundamental needs of influence, security, and serenity, is also frequently used to refer to the indicator (Schmidt, Wittman & Wolff, 2019). The willingness to try new things is the first component of the

FFM. The readiness or openness to try new things and go through new changes is referred to as this personality attribute (Abyaa, Idrissi & Bennani, 2018). One who has an adventurous, innovative, and creative disposition is capable of having a high level of openness to new things (Wang, Sapienza, Culotta & Ferrara, 2019). Conversely, conservative and conventional traits reveal a limited level of openness to experience (Peever, Johnson & Gardner, 2012). Conscientiousness, also referred to as how someone concentrates on their work or goals, is the second component of FFM. People with high conscientiousness are extremely disciplined, highly goal-focused, and concerned with others' achievement orientation (Salleh, Mendes, Grundy & Burch, 2010) conversely, those who score poorly on conscientiousness frequently display carelessness, a failure to prioritize skills, and disrespect for authority (Peever et al., 2012) The third component of FFM is extraversion, which is a quality shared by those who have a trusting and optimistic outlook on others and is characterized by sociability, assertiveness, and talkativeness (Acuña, Gomez, Hannay, Juristo & Pfahl, 2015). Extraversion demonstrates a person's warmth and social skills (Harb & Alhayajneh, 2019). An extraverted personality is exuberant, animated, and aggressive (Garrido, Bernard & Davidson, 2013) low extraverts, on the other hand, are less interested in social connections and are more likely to exhibit introverted traits like silence, shyness, and timidity. Being agreeable is frequently linked to a tendency to be diligent and cooperative. Additionally, it shows respect for other people's points of view (Gulati, Bhardwaj, Suri & Lather, 2016). A person's level of mental maturity can be determined by their level of neuroticism. Negative emotions like depression and anxiety are most likely to be experienced by those with high degrees of neuroticism (Ziemkiewicz, Ottley, Crouser, Chauncey, Su & Chang, 2012). A person with a high neurotic score will likely react emotionally to situations and be unable to handle difficult situations rationally. Low neuroticism describes a calm, less sensitive someone who is totally devoid of unpleasant feelings.

Information visualization uses cutting-edge computer graphics to research, examine, and convey phenomena that are frequently challenging to understand (Laramee, 2014). According to a recent study published in the Journal of Data Science (Cheng et al., 2021), the focus of visualization tools today is on providing intuitive, interactive, and aesthetically pleasing visualizations that can effectively convey complex data to a diverse audience. These tools are designed to support data exploration, analysis, and decision-making processes by helping users understand and communicate the insights and patterns hidden within large and often complex datasets. The routine of analysis and visual encoding are supported by the use of spreadsheets and visualization tools. The ability of information visualization to tell data stories is being promoted more and more. Information visualization is made to facilitate a variety of findings and viewpoints. In information visualization, the use of appropriate images, typography, space, style, and color is intended to boost a design's visual appeal and usability (Guney, 2019). A greater understanding of the relationship between software and its users is made possible by the visual design (Kennedy, 2020). In order to prioritize the design of the user interface and its flexibility in matching the users, designers may find it useful to investigate the relationship between visual designs and users' personality. In order to effectively use information visualization, data

storytelling has emerged as a powerful technique (Echeverria, Martinez-Madonado, Shum, Chiluiza, Granda & Conati, 2018).

The act of using data or information to tell a story is known as data storytelling. This action aids in the viewer's comprehension of the information being displayed. Data storytelling makes use of visualization as a tool to improve the storytelling because it's crucial for letting the audience understand the story. The human component, including the effectiveness of the viewpoints, visual style, beauty, and visualization literacy, must be taken into account while creating successful narrative (Bach, Riche, Carpendale & pfister, 2017). They must strike a balance between aesthetics, design principles, audience involvement, and visual commentary. The project's purpose or objective must be consistent with the visualization for planners and analysts to be able to give clear instructions on what needs to be conveyed and what is not yet available (Echeverria, Martinez-Maldonado, Granda, et al., 2018). The creative support, including visualization integration, templates, editing tools, and design patterns, was the most crucial component. The finest possible data visualization is required to improve the storytelling.

III.   METHOD

In this study, a quantitative research strategy was employed. Quantitative research aids in population association analysis, cause-and-effect analysis, and measurement of the relationship between independent and dependent variables (Polit and Hungler 2013; Moxham 2012). This research used survey research as a method because it was considered an appropriate tool for gathering information on views, knowledge, intention, user experiences, usability testing, and the frequency of use within a specific domain over time. The decision to use survey research was based on the design chosen for the study (Müller, Sedley & Ferrall-Nunge, 2014).

Undergraduate students from one local institution make up the study's population. There are 112 participants in the samples. The target sample was chosen to be undergraduate students to limit the sample's heterogeneity caused by differences in educational attainment, reduce administrative costs, and account for anticipated lower response bias. The Five-Factor Model International Personality Item Pool (FFM IPIP-NEO) form was used to extract the five personality traits; extraversion, agreeableness, openness, conscientiousness and neuroticism. The participants' personality scores were gathered using this instrument. The questionnaire's results will provide an estimate of the respondent's proficiency in each of the five FFM personality domains. There will be a subdomain for each domain. An abbreviated version of the original IPIP-NEO with 120 items was used in this investigation. The shortened version, according to its website, was developed to evaluate the same qualities as the regular version more effectively with fewer elements. The website did note, though, that the old method is more reliable. The condensed version was chosen due to time restrictions as well as to avoid participant disinterest and inattention.

The questionnaire was adapted from a prior study on the impact of user preferences for the evolution over time and comparison contexts used for idioms used for hierarchy by Gonc, 2020. Each visualization's visual examples were included in the survey, which was divided into three contexts.

The participants will first read the corresponding questions before selecting their favourite visual designs on a 7-point Likert scale, with 1 being the least favourite and 7 being the most. User context, Font, Buttons and Icons, Information Density, Navigation Bar Position, Hierarchy Visualization, Change over Time Visualization, and Comparison Visualization were adapted from the original questionnaire, and Storytelling Elements Preferences was the additional section of the redesigned survey. The participants select the groups to which each of the primary 5 attributes their score belongs based on user context (Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to experience). Extraversion relates to a person's outgoing and sociability. Agreeableness relates to a person's likability, cooperation and compassion. Conscientiousness relates to a person's responsibility, work ethic and self-discipline. Openness relates to a person/s imagination, creativity, and appreciation of new experience. Neuroticism relate to a person's emotional stability and tendency to experience negative emotions.

IV. RESULTS

Between November 2021 and January 2022, 113 undergraduate students participated in a 3-month-long data collection process using online surveys through website such as Facebook, Twitter, Whatsapp and Telegram.

A. Frequency analysis

Frequency analysis is a statistical technique used to identify the distribution of personalities and visual designs among a population. This method, described by Oosterbaan in 2002, allows for predictions about the likelihood of certain values occurring and helps assess the accuracy of those predictions (Oosterbaan, 2002). Sutrisno et al. (2020) discuss the usefulness of this technique for understanding the way data is divided into different categories (Sutrisno, Ashadi, Tanjung & Tyas, 2020).

TABLE I.   MAJORITY OF PARTICIPANT'S PERSONALITY

Variables	Values	
	Frequencies (out of 112)	*Percentage (%)*
Low Extraversion	36	32.1
Moderate Extraversion	35	31.3
Moderate Agreeableness	35	31.3
High Agreeableness	35	31.3
High Conscientiousness	36	32.1
Moderate Neuroticism	39	34.8
Low Openness	29	25.9

Table I shows the personality trait of majority of the participants. The majority of the participants in the study had low to moderate scores for extraversion, with 36 and 35 individuals respectively, representing 32.1% and 31.3% of the total sample. Individuals who have a low score for extraversion tend to be reserved and take their time in considering their thoughts before speaking. They may be quieter and more introspective compared to those with higher extraversion scores. For agreeableness, the majority of participants had moderate to high scores, with 35 individuals

in each group, making up 31.3% of the total. Individuals who have a high score for agreeableness are typically very interested in others and enjoy helping them and making them happy. They may be empathetic and caring, and value maintaining positive relationships with others. A large portion of the sample, 32.1%, had high levels of conscientiousness, with 36 individuals in this group. Those with high levels of conscientiousness are often well-organized and attentive to details. They may be reliable and responsible, and take care to ensure that their work is thorough and accurate. The majority of participants had moderate scores for neuroticism, with 39 individuals in this group, accounting for 34.8% of the total. Neuroticism is a personality trait that is associated with negative emotions and moodiness. People with high levels of neuroticism may be prone to sadness, anxiety, and emotional instability. In this study, the majority of participants had balanced levels of neuroticism, indicating that they were generally emotionally stable and mentally healthy. Finally, the majority had low scores for openness, with 29 individuals in this group, representing 25.9% of the total sample. These results indicate that the participants are generally balanced in terms of their personality traits. Individuals with low levels of openness tend to dislike changes and may be resistant to new ideas. They may prefer routines and familiar ways of doing things, and may be less curious and open-minded compared to those with higher openness scores.

TABLE II.   LOWEST NUMBER OF PARTICIPANTS' PERSONALITY TRAIT

Variables	Values	
	Frequencies (out of 112)	*Percentage (%)*
Very high Extraversion	4	3.6
Very high Agreeableness	9	8.0
Very high Conscientiousness	10	8.9
Very low Neuroticism	4	3.6
Very high Openness	16	14.3

Table II shows the personality traits that had the lowest number of participants in the study. These traits may have been less common among the sample, or may have had a smaller representation compared to other traits. It is important to note that the specific traits and numbers listed in Table II may vary depending on the study being discussed.

In the sample, the lowest score was for very high extraversion, with a frequency of 4 and 3.6% of the total sample. The lowest agreeableness score was also very high, with a frequency of 9 and 8.0% of the group. The lowest conscientiousness score was very high, with a frequency of 10 and 8.9% of the group. The lowest neuroticism score was very low, with a frequency of 4 and 3.6% of the total sample.

The personality frequency analysis shows that most of the participants have moderate to low levels of extraversion, and moderate to high levels of agreeableness. They also have high levels of conscientiousness, moderate levels of neuroticism, and low levels of openness. These results suggest that the participants tend to be reserved and prefer solitude. They are also resistant to change and often oppose new ideas. However, they are helpful to others and have a high level of empathy. They are thoughtful and have good impulse control and goal-

directed behaviour. They have a medium level of emotional capacity, which means their mood may fluctuate slightly. Overall, the participants can be described as realistic.

TABLE III.   MAJORITY OF PARTICIPANT'S VISUAL DESIGN CHOICE

Variables	Values	
	Frequencies (out of 112)	Percentage (%)
Highest preference Arial font	30	26.8
High preference Calibri font	33	29.5
Highest preference Calibri Light font	33	29.5
Low preference small font size	34	30.4
Somewhat low preference medium font size	28	25.0
Highest preference big font size	32	28.6
Highest preferences button with icon	25	22.3
No preference button with text only	24	21.4
Highest preference button with icon and text	41	36.6
No preference low density	27	24.1
Somewhat high preference average density	35	31.3
No preference high density	20	17.9
Highest preference top position nav bar	45	40.2
High preference bot poition nav bar	23	20.5
Lowest right side pos nav bar	39	34.8
Lowest left side pos nav bar	31	27.7
Somewhat high preference tree map	22	19.6
High preference	24	21.4
Lowest preference radial diagram	24	21.4
Somewhat high prefernce sunburst	28	25.0
Somewhat high preference line chart	30	26.8
Somewhat high prefernce line chart with point	31	27.7
High preference area chart	26	23.2
Somewhat high preference radar chart	31	27.7
Lowest preference word cloud	27	24.1
Highest preference horizontal bar chart	36	32.1
Highest preference verticall bar chart	44	39.3

Variables	Values	
	Frequencies (out of 112)	Percentage (%)
Highest preference Pie chart	48	42.9
High prefernce Magazine style	31	27.7
Somewhat high preference Annotated chart	27	24.1
Highest preference flowchart-infographic	40	35.7
Somewhat high preferences partitioned poster	30	26.8
Highest preference comic & animation	46	41.1

The majority of participants chose the highest preferences for Arial font with a 30 frequency, accounting for 26.8% of the group. Calibri font also had high preferences among the majority of participants, with 33 frequencies and accounting for 29.5% of the total group. Calibri Light was also chosen by the majority of participants with a frequency of 33, accounting for 29.5% of the group. However, the majority of participants with a frequency of 34 chose low preferences for small font size, accounting for 30.4% of all participants. The majority of participants chose somewhat low preferences for medium font size, accounting for 25.0% of all participants. However, a larger majority of participants (32 frequency) chose the highest preferences for large font size, accounting for 28.6% of the total group. In terms of buttons, the majority of participants chose the highest preference option using buttons with icons, with a frequency of 25 and accounting for 22.3% of total participants. A similar number of participants (24 frequency) had no preference for buttons with text only, accounting for 21.4% of the total group. On the other hand, the majority of participants (41 frequencies) chose the highest preferences for buttons with icons and text, accounting for 36.6% of all participants. Finally, a significant portion of the participants (24.1% of the total group) had no preferences for low density information with a frequency of 27. The majority of participants, accounting for 31.3% of the total group, somewhat preferred using average density information with a frequency of 35. However, a smaller majority of participants (17.9% of the total group) neither rejected nor preferred using high density information with a frequency of 20. In terms of the position of the navigation bar, the majority of participants (40.2% of the total group) chose the highest preferences for the top position, with a frequency of 45. A similar number of participants (20.5% of the total group) chose high preferences for the bottom position, with a frequency of 23. On the other hand, the majority of participants (34.8% of the total group) chose the lowest preferences for the right position of the navigation bar, with a frequency of 39. Finally, the majority of participants (27.7% of the total group) chose the lowest preferences for the left position of the navigation bar, with a frequency of 31.

The majority of participants chose somewhat high preferences for Tree map and Circular Packing diagram, while the majority chose high preferences for Sunburst and Radial diagram. The majority also chose somewhat high preferences for line chart and line chart with points, as well as high preferences for area chart. The frequencies for these preferences ranged from 22 to 31. The majority of participants

chose somewhat high preferences for radar chart, while the majority chose lowest preferences for word cloud. The majority also chose highest preferences for horizontal bar chart and pie chart. The frequencies for these preferences ranged from 27 to 48. The majority of participants chose highest preferences for magazine style, while the majority chose somewhat high preferences for annotated chart. The majority also chose highest preferences for flowchart-infographic, somewhat high preferences for partitioned poster, and highest preferences for comic and animation. The frequencies for these preferences ranged from 27 to 46.

B. Descriptive analysis

Table IV shows the number of participants (N), the minimum and maximum scores for personality and visual design preferences, and the mean and standard deviation for these scores. The minimum score indicates the lowest score and vice versa.

TABLE IV.   DESCRIPTIVE STATISTIC OF PERSONALITY TRAIT

Variables	Values				
	N	Min	Max	Mean	Std dev
Extraversion	112	1	5	2.76	1.033
Agreeableness	112	1	5	3.05	1.146
Conscientiousness	112	1	5	3.02	1.215
Neuroticism	112	1	5	3.46	1.073
Openness	112	1	5	2.79	1.359

The results indicate that the sample as a whole has a low level of extraversion, with a mean of 2.76 and a standard deviation of 1.03. The sample also has average levels of agreeableness and conscientiousness, with means of 3.05 and 3.02 and standard deviations of 1.15 and 1.22, respectively. The sample has a high level of neuroticism, with a mean of 3.46 and a standard deviation of 1.07. The results also show that the sample has a low level of openness, with a mean of 2.79 and a standard deviation of 1.34.

TABLE V.   DESCRIPTIVE STATISTIC OF VISUAL DESIGN ELEMENTS

Variables	Values				
	N	Min	Max	Mean	Std dev
Arial	112	1	7	5.17	1.530
Calibri	112	1	7	5.42	1.393
Calibri Light	112	1	7	4.96	1.847
Small font size	112	1	7	2.90	1.781
Medium font size	112	1	7	4.37	1.616
Big font size	112	1	7	5.26	1.552
Button with icon only.	112	1	7	4.77	1.855
Button with text only	112	1	7	4.95	1.615
Button with icon and text	112	1	7	5.10	2.022
Low density	112	1	7	4.63	1.594
Average density	112	1	7	4.98	1.185
High density	112	1	7	4.30	1.888

Variables	Values				
	N	Min	Max	Mean	Std dev
Top position of the navigation bar	112	1	7	5.56	1.639
Bottom position of the navigation bar	112	1	7	4.24	2.059
Right side positioning of the navigation bar	112	1	7	3.04	1.984
Left side positioning of the navigation bar	112	1	7	3.52	2.152
Tree map	112	1	7	4.17	1.999
Circular Packing	112	1	7	4.49	1.836
Sunburst	112	1	7	4.57	1.819
Radial diagram	112	1	7	3.47	1.850
Line chart	112	1	7	5.21	1.479
Line chart with point	112	1	7	4.89	1.678
Area chart	112	1	7	5.08	1.617
Radar chart	112	1	7	4.89	1.662
Horizontal bar chart	112	1	7	3.46	1.888
Vertical bar chart	112	1	7	5.55	1.381
Pie chart	112	1	7	5.81	1.379
Magazine style	112	1	7	5.15	1.589
Annotated chart	112	1	7	4.78	1.708
Flowchart-infographic	112	1	7	5.32	1.815
Partitioned Poster	112	1	7	5.09	1.680
Comic & Animation	112	1	7	5.91	1.212

The results for font type indicate significant preferences for all three types. Arial and Calibri font types showed that participants prefer to use both of these font types, with means of 5.17 and 5.42 and standard deviations of 1.53 and 1.39, respectively. Calibri Light font type showed that participants neither prefer nor reject it, with a mean of 4.96 and a standard deviation of 1.85. The results for font size showed differences among all three font sizes. Participants rejected the use of small font size, with a mean of 2.90 and a standard deviation of 1.85. They neither preferred nor rejected the use of medium font size, with a mean of 4.37 and a standard deviation of 1.62. They preferred to use big font size, with a mean of 5.26 and a standard deviation of 1.55. For button style, participants neither preferred nor rejected the use of both button with icon and button with text only, with means of 4.77 and 4.95 and standard deviations of 1.86 and 1.62, respectively. However, they preferred to use button with both icon and text, with a mean of 5.10 and a standard deviation of 2.02. The results for information density type showed that participants neither preferred nor rejected all three types: low density, with a mean of 4.63 and a standard deviation of 1.59; average density, with a mean of 4.98 and a standard deviation of 1.18; and high density, with a mean of 4.30 and a standard deviation of 1.89. For the position of the navigation bar, there were differences among all positions. Participants preferred to use the top position of the navigation bar, with a mean of 5.56 and a

standard deviation of 1.64, over the right and left side positions of the navigation bar, with means of 3.04 and 3.52 and standard deviations of 1.98 and 2.15, respectively. They neither preferred nor rejected the use of the bottom position of the navigation bar, with a mean of 4.24 and a standard deviation of 2.06.

For hierarchical visual elements, participants neither preferred nor rejected the use of tree map, circular packing diagram, and sunburst, with means of 4.17, 4.49, and 4.57 and standard deviations of 2.00, 1.84, and 1.82, respectively. However, they rejected the use of radial diagram, with a mean of 3.47 and a standard deviation of 1.85. For change over time visual elements, participants preferred to use both line chart and area chart, with means of 5.21 and 5.08 and standard deviations of 1.485 and 1.62, respectively. However, they neither preferred nor rejected line chart with points, with a mean of 4.89 and a standard deviation of 1.68. For comparison visual elements, participants preferred horizontal bar chart and vertical bar charts, with means of 5.55 and 5.81 and standard deviations of 1.38 and 1.26, respectively. They rejected the use of word cloud, with a mean of 3.46 and a standard deviation of 1.89, and neither preferred nor rejected the use of radar chart, with a mean of 4.89 and a standard deviation of 1.66. For storytelling visual elements, participants preferred to use magazine style, flowchart-infographic, partitioned poster, and comic animation, with means of 5.15, 5.32, 5.09, and 5.91 and standard deviations of 1.59, 1.82, 1.68, and 1.21, respectively. They neither preferred nor rejected the use of annotated chart, with a mean of 4.78 and a standard deviation of 1.71.

C. Correlation analysis

To assess the association between the five personality traits based on the FFM (extraversion, agreeableness, conscientiousness, neuroticism, and openness) and the visual designs font, Pearson correlation was computed. The findings showed that extraversion qualities and the Calibri light font type have a substantial, favorable link, with $r(110) =.29$ and $p =.042$, respectively. A substantial, positive association between the openness attribute and the Arial font type was observed, with $r(110) =.22$, $p = 0.19$. The findings indicate a statistically significant, favorable connection between the openness attribute and small font size, with $r(110) =.19$, $p =.042$. Small font size has no relationship to extraversion, agreeableness, conscientiousness, or neuroticism. Both high font size and medium font size do not correlate with any personality traits.

TABLE VI.   CORRELATION BETWEEN PERSONALITY AND VISUAL DESIGN ELEMENT

Visual design with personality	Correlation value
Calibri Light with Extraversion	$r(110) =.29$, p $=.042$
Arial with Openness	$r(110) =.22$, p $=.019$
Small font size with openness	$r(110) =.19$, p $=.042$
Button with text, with extraversion	$r(110) = .31$, p $= .001$
Button with text, with conscientiousness	$r(110) = .24$, p $= .010$
Button with text, with openness	$r(110) = .28$, p $= .003$

Visual design with personality	Correlation value
High density with extraversion	$r(110) = .21$, p $= .024$
Bottom navigation bar with extraversion	$r(110) = .19$, p $= .042$
Right navigation bar with openness	$r(110) = .23$, p $= .016$
Sunburst with extraversion	, $r(110) = .20$, p $= .032$
Radial diagram with openness	$r(110) = .21$, p $= .030$
Line chart with extraversion	, $r(110) = .31$, p $= .001$
Line chart with openness	$r(110) = .23$, p $= .013$
Radar chart with extraversion	$r(110) = .19$, p $= .047$
Word Cloud with agreeableness	$r(110) = .20$, p $= .040$
Partitioned poster with agreeablenss	$r(110) = .20$, p $= .035$
Magazine style with conscientiousness	$r(110) = -.24$, p $= .010$

The findings demonstrate a statistically significant, favorable link between extraversion and the button with text only style, with $r(110) =.31$, $p =.001$. With a significant and positive correlation of $r(110) =.24$, $p = .010$, the association between conscientiousness and button with text style is also demonstrated. The results also show a substantial, positive association between openness characteristic and button with text style, with a value of $r(110) =.28$, $p = .003$. $r(110) =.23$, $p =.024$ indicates a statistically significant, positive connection between extraversion characteristic and high density. A significant, gratifying association between openness and the right position of the navigation bar is produced, with $r(110) =.23$ and $p =.016$. The results also show a substantial, positive association between extraversion characteristic and bottom navigation bar with extraversion, with a value of $r(110) =.19$, $p = .042$.

Tree maps and circular packing elements in hierarchy visual style have no relationship to any of the five personality traits. Tree maps and circular packing are visualization techniques used to display hierarchical data structures. Tree maps use rectangles to represent data items, with the size of each rectangle proportional to the data value. Circular packing uses circles to represent data items, with the size of each circle proportional to the data value. A recent study (Lee et al., 2020) found that tree maps are generally more effective at displaying data with a large number of hierarchical levels, while circular packing is more effective at displaying data with a small number of hierarchical levels and a high degree of nesting. Sunburst visual style and extraversion attribute have a substantial, positive connection with $r(110) =.20$, $p =.032$. Radial diagram and openness attribute have a substantial, positive connection with $r(110) =.21$, $p =.030$. Line chart results indicate a substantial, positive association between extraversion and openness, with $r(110) =.31$, $p =.001$ for extraversion and $r(110) =.23$, $p =.013$ for openness, respectively. All five personality traits have no link with the vertical bar chart, horizontal bar chart or pie chart. $r(110) =.188$, $p =.047$, the results demonstrate a significant, positive connection between extraversion and radar chart. The results also show a significant, negative association between agreeableness and word cloud, $r(110) =.195$, $p =.040$. All five

personality qualities have no link with annotated charts, flowchart-infographics, or comics and animations in data narrative visual elements. According to the results, partitioned posters and agreeableness have a substantial, positive association with r(110) =.20, p =.035. Additionally, the results show a substantial, inverse relationship with r(110) = -.25, p =.010 between magazine style and conscientiousness.

D. Chi-square analysis

To understand how different personalities relate to preferences for visual design elements, we used the chi square test. Our analysis showed that there are significant correlations between personality traits and preferences for visual design elements. The chi square test allows us to analyze these relationships in more detail and identify any variations in personality traits that are associated with specific visual design elements. In this study, we specifically looked at the linear-by-linear association statistic because the variables are ordinal (Smith et al., 2021).

In this research, the questionnaire used a 7-point Likert scale to measure participants' favourability towards different visual styles. The options on the scale ranged from lowest preferences (1) to highest preferences (7), with options for low, somewhat low, and no preferences in between. The personality trait was also measured using a numerical scale, with 5 levels ranging from very low (1) to very high (5). For example, if a participant scored a 5 for extraversion, it would indicate that they have a very high level of extraversion.

TABLE VII. CHI-SQUARE TEST BETWEEN PERSONALITY AND VISUAL DESIGN ELEMENT

Visual design with personality	Preferences	N	P
Calibri Light with Extraversion	Highest	33	.042
Arial with Openness	Highest	30	.020
Small font size with openness	Low	34	.043
Button with text, with extraversion	No preference	24	.001
Button with text, with conscientiousness	No preference	24	.010
Button with text, with openness	No preference	20	.003
High density with extraversion	No preference	20	.024
Bottom navigation bar with extraversion	High	23	.042
Right navigation bar with openness	Lowest	33	.017
Sunburst with extraversion	Somewhat high	28	.032
Radial diagram with openness	Lowest	24	.030
Line chart with extraversion	Somewhat high	30	.001
Line chart with openness	Somewhat high	30	.013
Radar chart with extraversion	Somewhat high	31	.047
Word Cloud with agreeableness	Lowest	27	.040
Partitioned poster with agreeablenss	Somewhat high	20	.035
Magazine style with conscientiousness	High	31	.010

Table VII presents the results of the chi-square test between personality and visual design elements. It includes the visual design elements and their correlated personality traits, the majority preference option chosen by participants, the number of participants (N), and the P-value. Table VII allows us to see which visual design elements are correlated with specific personality traits and how strong these correlations are based on the P-value. It also shows the most preferred option for each visual design element among the participants.

The results of the chi-square tests suggest that there are significant relationships between certain personality traits and preferences for visual design elements. For example, the relationship between openness and Arial font was significant, with a p-value of .020. This indicates that openness is correlated with a preference for Arial font. Similarly, the relationship between extraversion and Calibri Light was significant, with a p-value of .042, suggesting a relationship between extraversion and a preference for Calibri Light font.

Other significant relationships were found between personality traits and preferences for small font size, button with text only, information density, and the position of the navigation bar. In each of these cases, the majority of participants had no preference, indicating that there may not be a strong preference among the participants for these specific visual design elements. However, the significant p-values indicate that there are still relationships between these elements and certain personality traits.

The majority of participants had a somewhat high preference for the sunburst visual style, while the least popular style was the word cloud. The line chart and partitioned poster were also somewhat popular, and the highest preference was for the magazine style. Overall, the study suggests that there may be a link between personality traits and visual style preferences.

TABLE VIII. LEVEL OF PERSONALITY TRAIT AND NUMBER OF PARTICIPANTS CHOSING VISUAL DESIGN ELEMENT

Visual design	Preferences	Personality	N
Calibri Light	Highest	Average E	13
Arial	Highest	Low O	8
Small font size	Low	Low O	10
Button with text	No preference	Low E	10
Button with text	No preference	Ave C	10
Button with text	No preference	Low, Ave & High O	6
High density	No preference	Low E	8
Bottom navigation bar	High	Ave E	9
Right navigation bar	Lowest	Low O	12
Sunburst	High	Ave E	9
Radial diagram	Lowest	Very Low & ave O	7
Line chart	Somewhat high	Ave E	9
Line chart	Somewhat high	Very low & Very high O	7
Radar chart	Somewhat high	Ave & High E	10
Word Cloud	Lowest	High A	10

Visual design	Preferences	Personality	N
Partitioned poster	Somewhat high	Ave A	11
Magazine style	High	High C	9

Table VIII indicates that the majority of participants have high openness traits and prefer the Arial font. The table above shows that participants with average extraversion levels are the majority for the Calibri Light font. The table indicates that participants with low openness and extraversion traits are the majority for small font size and button with text only. The table also shows that participants with low, moderate, and high openness traits are the majority for the no preference option for button with text only. The table shows that participants with low extraversion traits are the majority for the no preference option for high information density. The table indicates that participants with moderate extraversion traits are the majority for the high preference option for bottom navigation bar. Participants with low openness traits are the majority for the lowest preference option for right side navigation bar. Participants with very moderate extraversion traits are the majority for the somewhat high preference for sunburst. Participants with very low and moderate openness traits are the majority for the lowest preference option for radial diagram. Participants with moderate extraversion traits are the majority for the somewhat high preference option for line chart. Participants with very low and very high openness traits are the majority for the somewhat high option for line chart. Participants with high and moderate extraversion traits are the majority for the somewhat high option for radar chart. Participants with high agreeableness traits are the majority for the lowest preference option for word cloud. Participants with moderate agreeableness traits are the majority for the somewhat high preference option for partitioned poster. Participants with high conscientiousness traits are the majority for the high preference option for magazine style.

V. DISCUSSION

The analysis above shows how visual design elements are associated with differences in personality traits. It reveals which levels of personality influence the selection of visual design elements. This information can help designers create visual designs that are more tailored to different personality types. For example, a designer may use larger font sizes for participants with low openness traits, or use a bottom navigation bar for participants with moderate extraversion levels. Overall, understanding the relationship between visual design elements and personality traits can help designers create more effective and engaging designs.

The analysis of font styles shows that users with low openness prefer to use Arial font, as it is easy to read and is a safe choice. Meanwhile, users with moderate extraversion tend to prefer Calibri Light, which has a lighter and more modern appearance. For font size, users with low openness levels may want to avoid using small fonts, as they are harder to read and may not be suitable for all designs. Users with low openness may prefer to stick with traditional, conservative fonts. For button styles, users with high, moderate, and low openness levels, as well as those with moderate conscientiousness and low extraversion levels, have no preferences for buttons with text. However, the analysis overall suggests that users with low openness prefer buttons

with text. The analysis of information density style shows that users with low extraversion levels have no preference for high density information. This may be because people with low extraversion tend to be reserved and private, and may prefer to use high density information in their designs to avoid having to explain things in person. For the position of the navigation bar, users with moderate extraversion levels have a high preference for the bottom position. This position is a common choice, and allows users with average levels of extraversion to use it without overthinking. Users with low openness levels should avoid the right side position of the navigation bar, as it is the lowest preference option for them. This position is not commonly used in designs, and may be viewed as unorthodox, which may be why users with low openness do not prefer it.
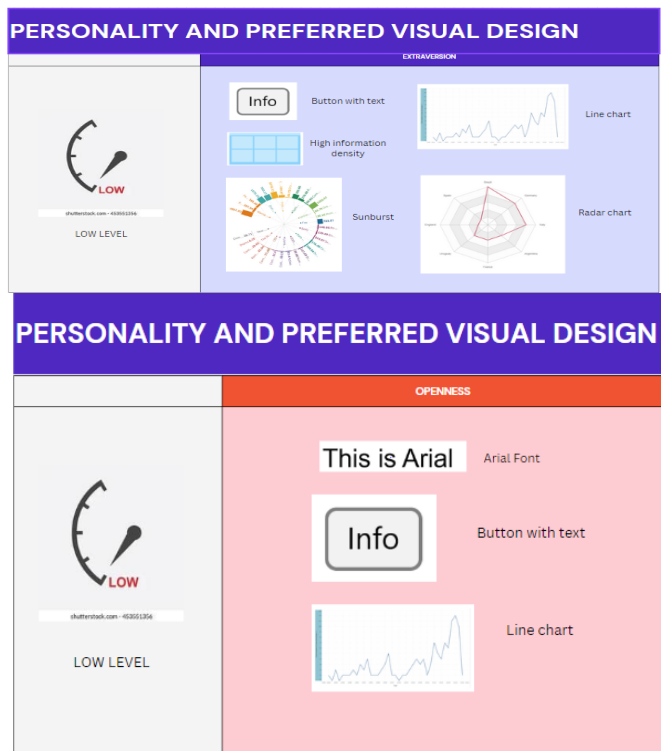

Fig. 1. Low level extraversion and openness trait with it preferred visual designs. Illustrations were designed by the author.

The analysis of hierarchical visualization shows that users with moderate extraversion levels prefer the sunburst visual style. This style presents the entire hierarchical data in a single-screen snapshot, which makes it a good choice for users who are flexible and balanced. The results for the radial diagram are inconsistent, with correlations to openness traits. The analysis shows that users with very low and moderate openness levels have the lowest preferences for the radial diagram, while users with low extraversion levels have somewhat high preferences for it. Radial diagrams are useful because they allow users to present multiple sets of data on one diagram, and compare the relative strengths of different variables at the same time. Users with low extraversion levels may choose this style because of these advantages, which allow them to present their data in a clear and concise way to their audiences.
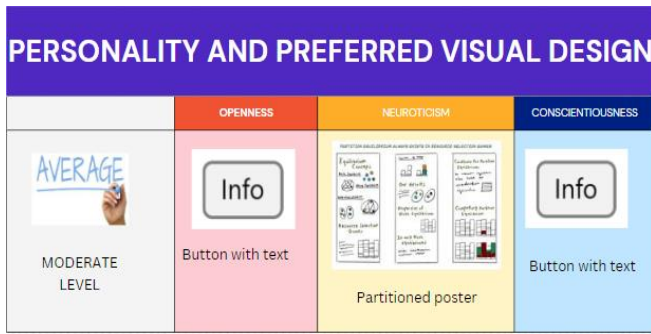
Fig. 2.   Average openness, neuroticism and conscientiousness trait with preferred visual designs. Illustrations were designed by the author

The analysis of change over time visualization shows that the line chart style is preferred by users with moderate and low extraversion levels. The analysis shows that users with moderate extraversion are the majority in the somewhat high preference option, which has the highest number of users. However, for the overall options, users with low extraversion have the most users choosing the highest preference option. Line chart style is the simplest way to show changes over time, and is preferred by users with moderate and low extraversion for quick analysis and easy observation of data. Line chart style is also preferred by users with both low and high openness levels. A detailed analysis shows that users with very low and very high openness levels are the majority in the somewhat high preference option, which has the highest number of users. However, for the overall options, users with high openness levels have the most users choosing the highest preference option.

The analysis of comparison visualization shows that users with moderate and low extraversion levels prefer the radar chart for comparison. The radar chart's outliers are immediately visible, and commonalities are easy to assess, which may be why users with these personality traits chose it. However, the majority of users with low extraversion levels chose the highest preference option, and they have the same number of users as those with moderate and low extraversion levels in the somewhat high preference option. The analysis also shows that users with high agreeableness have the lowest preferences for the word cloud. People with low agreeableness may not be willing to cooperate in social situations, and may not be drawn to the word cloud's design, which highlights frequently used words in larger or bolder fonts. For storytelling visualization, the magazine style is preferred by users with high conscientiousness levels. People with high conscientiousness are often seen as disciplined and self-controlled, and may prefer the magazine style for its conversational style and ability to quickly deliver information to readers. Partitioned posters are preferred by users with both average and high agreeableness. People with high agreeableness often put others' needs before their own, which may be why they chose the partitioned poster, as it accommodates peripheral views and allows easy access to information without straining cognitive function. The analysis shows that neuroticism trait levels do not affect users' preferences for any visual design in this research, indicating that mental health is not a major factor in visual design selection.
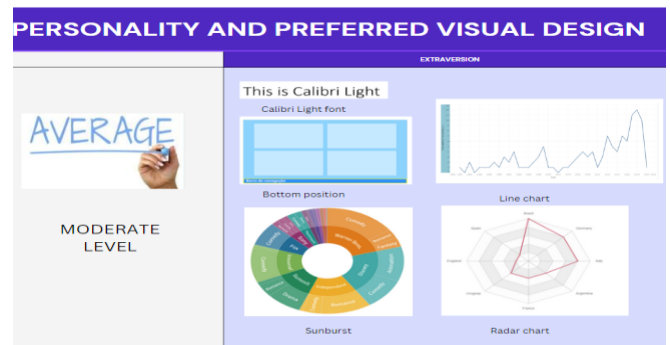

Fig. 3. Average openness trait with preferred visual designs. Illustrations were designed by the author

It is important to note that these findings are based on a specific study and may not apply to all individuals or situations. Personality traits can vary greatly among individuals, and the relationship between visual design elements and personality traits is complex and can be influenced by many factors. Additionally, the preferences of participants in this study may have been influenced by factors such as their personal experiences, cultural backgrounds, and individual preferences. As such, it is important to carefully consider these findings when designing visual elements, but not to make generalizations about individuals based solely on their personality traits.
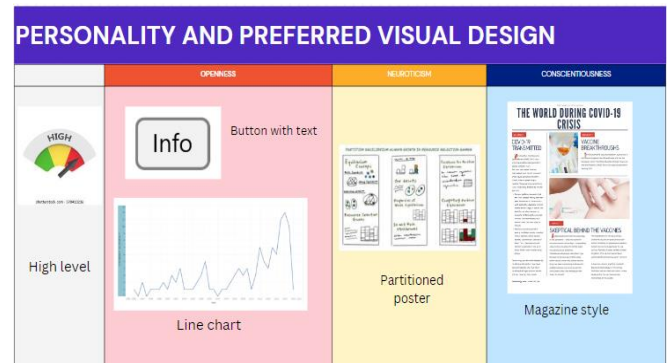

Fig. 4. High openness, neuroticism and conscientiousness trait with preferred visual designs. Illustrations were designed by the author.

VI.   CONCLUSION

In conclusion, this study examined the connection between personality and user preferences for data visualization and storytelling. Correlation and descriptive statistical analysis were used in this study. Based on the findings, the other four personality qualities from the five-factor model other than neuroticism show an association with visual design elements. It may be possible to improve user personalization of visualization tools by using these findings. It may help in shorten the time spent on searching which visual elements that the user prefer by introducing suggestion box of visual style based on their personality. Time restrictions brought on by the COVID-19 outbreak and the volume of respondents also impacted the research. Due to these restrictions, future study should use additional methodology and testing to address any potential pitfalls and have a larger sample size.

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