

Visual Perception of Organic and Polygonal Shapes in the Graphic Communication Processes

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Abstract: Many factors influence the visibility and proper reception of visual messages. The forms used in communication play a crucial yet often overlooked role in this process. This paper investigates which forms are more favourably perceived by the public in graphic communications. A test questionnaire was developed to gauge respondents' preferences for different shapes. The study involved 63 participants whose visual attention to organic and polygonal shapes was measured using an eye-tracker over an 8-second interval. Three scripts were utilized: two freely available ones and one specifically written for this research. These scripts were implemented in MATLAB to analyse and present the visual results of the study. The hypotheses were tested using two statistical methods: the t-test for two vectors and Wilcoxon's rank-sum test. Based on the findings, recommendations were outlined for future research on the application of organic and polygonal shapes in graphic communications.

Keywords: graphic communication; organic shapes; polygonal shapes; visual perception

1 INTRODUCTION

Every day, we encounter a variety of visual stimuli in the form of organic and polygonal two-dimensional shapes. While some shapes are more easily perceived than others, the question arises: are organic or polygonal shapes more acceptable to us? This research aims to help enhance the effectiveness and speed of visual perception in graphic communications and the products derived from these interactions (client–designer–consumer). The objective is to identify the parameters and relationships between organic and polygonal flat shapes that influence the visual perception of the final graphic product.

In today's fast-paced world, the flow of information is incredibly rapid, leaving people increasingly overwhelmed and often causing important details to be overlooked. While the lightning-fast progress of technology brings many advantages, it also presents challenges, as human attention is constantly inundated with vast amounts of information. Distinguishing between various forms of visual stimuli is challenging, as they often merge into a unified structure or visual impression that incorporates technical, artistic, and, most importantly, multidisciplinary elements.

Quick judgments about objects in the environment are influenced by their physical properties, although the exact nature of these properties remains unclear. For example, sharp transitions in contours can evoke a sense of threat, potentially triggering negative biases. The type of contour a visual object possesses – whether it features sharp angles or smooth curves – plays a decisive role in shaping people's attitudes toward it. These first impression tendencies are heavily influenced by the perceptual characteristics of the image, particularly when judgments are made quickly. Research has shown that the shape of an object serves as a significant factor in forming preferences [1, 2].

In the context of graphic reproduction, visual psychophysics – or the psychophysics of visual perception—plays a crucial role. This field, defined as a descriptive science aimed at understanding the sensory capabilities of the

normal human visual system [3-5], serves as a key element in this paper for validating the hypothesis.

2 THEORETICAL FRAMEWORK

This paper is based on the research conducted as a part of the dissertation "Determination of visual perception of organic and polygonal shapes in graphic communication processes" [6].

Shape is a fundamental property of visual appearance. Eye movement patterns provide valuable insights into shape analysis strategies during visual perception. However, there is still limited understanding of how shape perception differs between tasks involving motion recognition and those requiring action planning.

Leek et al. discovered that high curvature – particularly extremely concave minimums – can predict eye movement patterns during object recognition tasks. Their study investigated how eye movements might reveal differences in shape analysis strategies between object recognition and action planning. In the context of object recognition, shape detection and recognition are crucial, as they enable the system to identify an object within a given image [7].

The selection of visual aids – such as statistical graphs, images, and symbols – serves as a key tool in graphic communication. A carefully designed message elicits a specific reaction from the target audience. On a subconscious level, individuals seek elements that resonate with their identity. The visual components of packaging aim to evoke a sense of familiarity and connection, creating the impression of "this is my kind of product" while also conveying the product's usefulness. This connection represents the most significant impact of graphic communication.

Visual aids enrich communication by adding depth and clarity to the message. Every object used in graphic communication is thoughtfully designed, carries a story, and serves to encourage interaction or convey a message in a simple yet impactful way. From the moment we wake up, everything that surrounds us communicates visually. Graphic

communication has profoundly enhanced every phase of daily human life. It allows for the expression of personality and ideas that go beyond the limits of words alone. Good design is characterized by innovation, honesty, and aesthetic appeal. When a message is conveyed with clarity and sincerity through graphic communication, people tend to respond positively, forging a deeper connection to the message [8-11].

Graphic communication is showing people the things they urgently need to understand, in ways that they can understand. Graphic communication is the process through which we can decode the visual culture of those we need to communicate with. Sometimes, most of the time, this means using tools and processes that have their origins in graphic design [12]. Shape, as one of the graphic design elements, refers to the external outline of the form or anything that has height and width [13].

3 RESEARCH METHODOLOGY

3.1 Goal and the Hypothesis of the Research

The main goal of this paper is to explore the relationship between the visual perception of organic and polygonal flat shapes in graphic communication processes and to evaluate their visual legibility within graphic communications and across various multimedia systems.

The hypothesis that has been put forward and that will be tested is as follows:

H: *Organic shapes exert a stronger influence on the visual perception of observers compared to polygonal shapes in graphic communication processes.*

3.2 Methodology

The research for this paper was conducted in the laboratory of the University North in Varaždin, involving students from the undergraduate programme in Multimedia, Design, and Application and the graduate programme in Multimedia. A total of 43 first-year undergraduate students participated, all of whom possessed basic knowledge of visual perception but had not yet developed expertise to distinguish the nuanced phenomena occurring in this aspect of graphic communications. Additionally, 20 graduate students, who had gained deeper insights into the processes of visual communication and visual psychophysics after achieving learning outcomes at the undergraduate level, were also surveyed. Of the 63 participants, 33 were male (52.4%) and 30 were female (47.6%), with ages ranging from 18 to 30 years.

The research was conducted in several phases. The first phase entailed the creation of visual templates tailored for the study. In the second phase, participants were presented with a visual questionnaire without any prior explanation of the research objectives. The questionnaire consisted of both textual and visual elements (Fig. 1) and was designed in a minimalist style to help the respondents focus more effectively on the provided shapes.

In this phase of the research, samples were created to display organic and polygonal flat shapes side by side in a monochromatic environment.

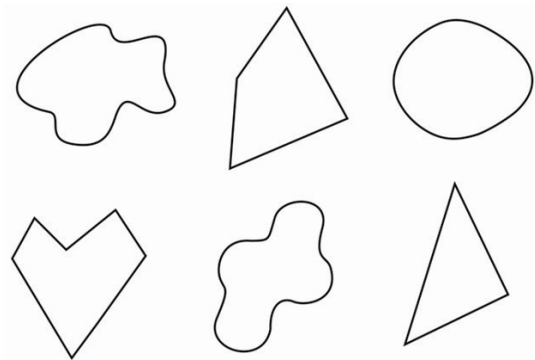


Figure 1 Visual part of the survey questionnaire

The textual portion of the questionnaire included mandatory demographic questions, such as the respondents' gender and age. Below the visual samples, participants were presented with the following questions/tasks/statements:

- *Which shape caught your attention the most and is visually the most acceptable to you?*
- *In a few words, describe why you chose this shape.*
- *Polygonal shapes evoke in me: emotion, fear, threat, happiness, discomfort.*
- *Organic shapes evoke in me: emotion, fear, threat, happiness, discomfort.*

Additionally, a blank field was provided for participants to describe their own impressions or emotions in free text. Once the respondents completed the questionnaire, each was assigned a unique number corresponding to the same number used in the subsequent phase of the research.

The research adhered to ISO 3664:2009 Graphic technology and photography - Viewing conditions. The eye-tracking methodology utilized the Gazepoint GP3 Desktop eye-tracking device in conjunction with a Samsung LCD monitor, model S22A350H (size 21.5", display ratio 16:9, and viewing angle 170°/160°). The Gazepoint Analysis software was used to monitor the eye movements of the participants (Fig. 2), as they viewed the test samples.



Figure 2 Testing place for the Tracking methodology

The test samples presented to the participants featured one organic shape and one polygonal shape, placed side by side. To eliminate any bias regarding the initial viewing direction, the positions of the shapes were alternated between trials (Fig. 3). The samples were separated by a white test shape featuring a cross in the centre to prevent the eyes from lingering on the location of the previous test shape after it changed on the screen.

Each participant had eight seconds to view each test sample, with the sample changing after that time. Eight seconds was chosen based on recent research suggesting that human attention spans have decreased with the rise of new technologies. If a consumer does not find something of interest within this brief time, they tend to dismiss it and move on. As mentioned, the eye-tracking device monitored specific eye pupil movements, capturing data on the first fixation, the longest fixation, and the total amount of time spent focusing on individual points of the test samples.

In the subsequent phases, the results from the visual questionnaire were analysed, along with the statistical processing of the eye-tracking data.

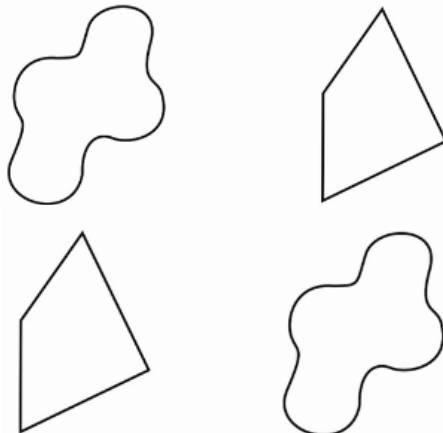


Figure 3 Test samples (visual templates)

4 RESULTS AND DISCUSSION

Fig. 4 shows the interface of the Gazeport Analysis Professional Edition (v6.0.0.), the software used for testing the participants. Developed by the company Gazeport, the programme works in conjunction with their eye-tracking device, which monitors eye movements and fixations. While the software is primarily designed for visual presentation of results and is not suitable for advanced statistical analysis or hypothesis testing, the data it collects is highly valuable and can be imported into professional statistical tools for further analysis.

Before testing, each participant undergoes pupil calibration, ensuring that the eye-tracking system accurately follows the designated test points on the screen. The program includes a subprogramme for calibration, and testing cannot begin until all parameters are met.

Participants were investigated with single point fixation thresholds of 30, 50, 70, 90, 110, 130, 150, 170, 190, 210, 230, and 250. Fig. 5 illustrates the density threshold of

fixations for 230 observations at a single point. The numerical data shows that 57 fixations were focused on the left organic shape, while 12 fixations were on the right polygonal shape.

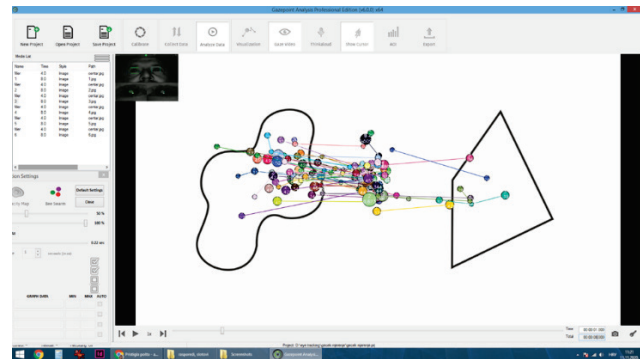


Figure 4 Presentation of fixations of Gazeport Analysis Professional edition application for the first study sample

Cluster 1: number of points: 57
Cluster 2: number of points: 12
Clusters

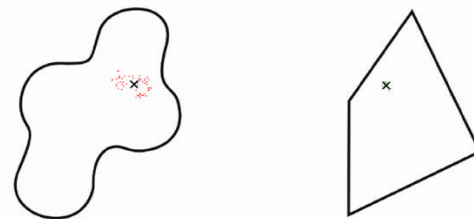


Figure 5 Fixation density threshold for 230 observations at a single point of the first study sample

The statistical analysis of the obtained data was conducted using MATLAB 2020a, with three scripts employed for the visual representation of the results. To test the hypotheses, the two-sample t-test for equal means and the Wilcoxon rank-sum test were applied, based on the results from 63 participants.

Table 1 Results of the t-test with a fixation threshold of 230 observations at a single point of the first study sample

Stupac1	hypothesis of equal mean	p-value	t-statistic left object	t-statistic right object	normal dist. left object	normal dist. right object	mean value first object	mean value second object	Statistically	Stupac2	Stupac3
1_image	reject	5,7E-07	5,31388797	No	No	0,6489385	0	mean_first>median_second			
2_image	reject	0,00002	18,6966931	18,6620934	No	No	0,17663175	0,65279533	mean_first>median_second		
3_image	reject	1,4E-05	4,8260924	8,2477081	No	No	0,5641245	3,3684518	mean_first>median_second		
4_image	reject	0,04036	5,0917023	4,5853827	No	No	0,29682397	0,71426791	mean_first>median_second		
5_image	reject	2,0E-06	5,0866667	No	No	0	0,37246373	mean_first>median_second			
6_image	reject	1,5E-05	4,3081104	No	No	0,60317463	0	mean_first>median_second			

Table 2 Results of Wilcoxon test with a fixation threshold of 230 observations at a single point of the first study sample

Stupac1	hypothesis of equal median	p-value	Median value first object	Median value second object	Statistically	Stupac2	Stupac3
1_image	reject	1,48E-08	0	0	0	median_first>median_second	
2_image	reject	0,001921	0	0	0	median_first>median_second	
3_image	reject	1,97E-05	0	0	0	median_first>median_second	
4_image	confirm	0,120982	0	0	0	no difference	
5_image	reject	1,5E-07	0	0	0	median_first>median_second	
6_image	reject	3,1E-07	0	0	0	median_first>median_second	

Tabs. 1 and 2 demonstrate a statistically significant difference in favour of the organic shape, with a fixation threshold of 230 observations at a single point, as shown on the left side of Fig. 5. This is further reflected in the number of fixations on each specific shape. Participants were examined using fixation thresholds of 30, 50, 70, 90, 110, 130, 150, 170, 190, 210, 230, and 250). Fig. 6 shows dot map of fixations for all participants for the first study sample.

Tab. 3 demonstrates a results of fixations for the first study sample, showing fixation thresholds from 30 to 250.

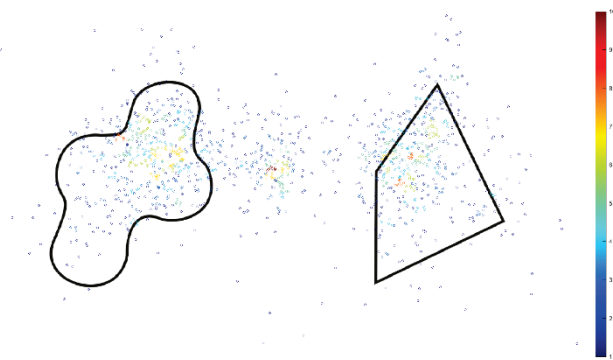


Figure 6 Dot map of fixations for all participants for the first study sample

Table 3 Results of fixations for the first study sample, showing fixation thresholds from 30 to 250

Threshold	N_points1	N_points2	N_points3	N_points3/N_points1*100%	Center1x	Center1y	Center2x	Center2y	Center3x	Center3y
30	507	237	476	93.88560158	448.87953	545.93286	470.63075	917.19375	455.19328	1381.1622
50	491	221	442	90.0203666	447.22504	553.69715	468.58997	922.32038	453.63305	1373.0483
70	459	192	392	85.40305011	445.51925	565.12282	475.28103	918.23181	444.32942	1361.3682
90	416	165	348	83.65384615	440.99616	574.63358	478.55886	903.51296	441.42483	1357.6311
110	389	135	306	78.66323907	438.76988	584.59126	483.86729	911.9445	439.16007	1355.4897
130	343	104	254	74.05247813	431.64386	588.60842	487.11196	922.66331	441.95099	1351.2783
150	285	73	219	76.84210526	426.02581	586.85504	492.36769	942.52175	447.50136	1350.5601
170	235	50	177	75.31914894	427.19752	581.7707	495.96444	944.79798	451.05181	1347.7852
190	183	30	120	65.57377049	430.1646	579.37959	500.28489	939.70236	455.50513	1343.4455
210	112	9	60	53.57142857	437.07345	585.38799	490.4269	934.99303	460.64412	1337.9025
230	57	0	12	21.05263158	448.65212	603.2396			452.49299	1365.1349
250	4	0	0	0	439.17696	630.05341				

Fig. 7 shows a thermal map of fixations of all participants in the first study sample.

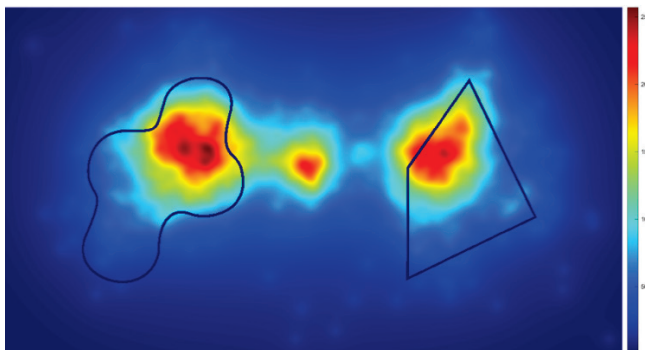


Figure 7 Thermal map of fixations of all participants in the first study sample

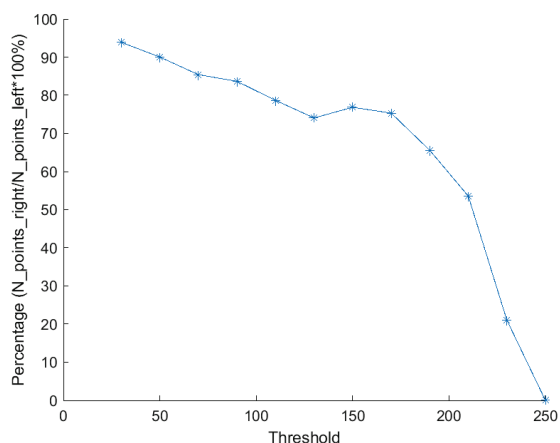


Figure 8 Percentage of fixations at different thresholds for all participants in the first study sample

Based on the results, the t-test (which favours the null hypothesis) demonstrated that the data in vectors x and y come from independent random samples with normal distributions, having equal means and equal but unknown variances. The alternative hypothesis suggests that the data in vectors x and y come from populations with unequal means. The result of the hypothesis test is recorded as 1 if the null hypothesis is rejected at the 5% significance level, using a two-tailed test, and 0 otherwise. In other words, a result of 1 indicates that the means are statistically different, while a result of 0 indicates no significant difference.

Fig. 8 shows the percentage of fixations at different thresholds for all participants in the first study sample.

The Wilcoxon rank-sum test, on the other hand, evaluates the null hypothesis that the data in vectors x and y are samples from continuous distributions with equal medians, against the alternative hypothesis that they are not. The test assumes that the vectors x and y are independent. The result of the hypothesis test is recorded as 1 if the null hypothesis is rejected at the 5% significance level (using a two-tailed test), and 0 otherwise. A result of 1 indicates that the medians of the two groups are statistically different, meaning there is a statistically significant difference in the fixations of subjects between the organic and polygonal forms, with the organic form showing a stronger effect. This outcome confirms hypothesis.

An analogous method was applied to a second test sample, where the positions of the shapes were swapped.

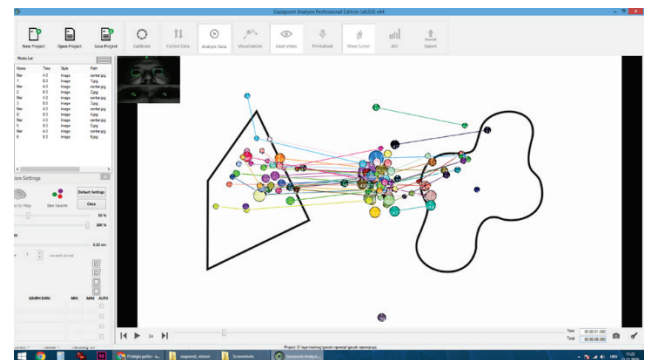


Figure 9 Presentation of fixations of Gazept Analysis Professional edition application for the second study sample

Fig. 10 shows dot map of fixations for all participants for the second study sample.

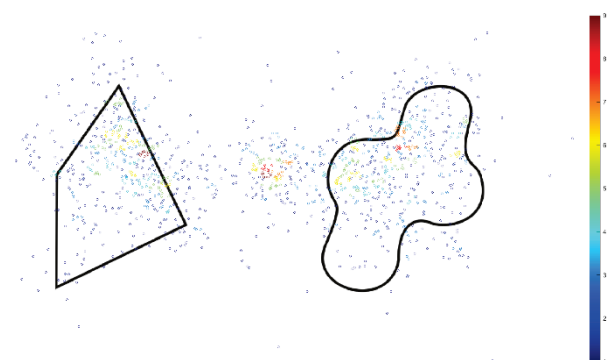


Figure 10 Dot map of fixations for all participants for the second study sample

Tab. 4 demonstrates a results of fixations for the second study sample, showing fixation thresholds from 30 to 250.

Fig. 11 shows a thermal map of fixations of all participants in the second study sample.

Table 4 Results of fixations for the second study sample, showing fixation thresholds from 30 to 250

Threshold	N_points1	N_points2	N_points3	N_points3/N_points1*100%	Center1x	Center1y	Center2x	Center2y	Center3x	Center3y
30	487	292	460	94,45585216	463,58523	491,15218	507,16448	1014,7	445,98749	1373,0032
50	460	282	445	96,73913043	462,86385	498,43141	504,2225	1017,8555	444,54968	1370,5424
70	410	261	411	100,2439024	465,52238	511,48844	496,30799	1012,8232	436,16587	1356,7854
90	364	231	401	110,1648352	454,36499	516,31627	494,18945	1001,1187	437,01091	1343,0967
110	312	207	343	109,9358974	445,01919	513,16115	490,81432	1015,1721	440,77968	1332,9086
130	269	168	294	109,2936803	445,14525	517,95041	490,12969	1000,3645	441,14864	1311,6203
150	235	121	263	111,9148936	443,58689	519,73964	483,34115	977,4239	447,02078	1281,5191
170	184	86	233	126,6304348	440,72868	517,76056	482,93176	960,82799	449,74159	1271,4937
190	144	67	188	130,5555556	443,24125	523,3004	483,65296	949,31124	449,49958	1270,2046
210	87	38	124	142,5287356	429,07059	515,81111	490,93382	944,95368	458,18136	1264,7942
230	25	25	45	180	414,2208	518,39244	492,31386	941,17334	445,37312	1255,172
250	0	0	4 inf						487,23204	1184,6863

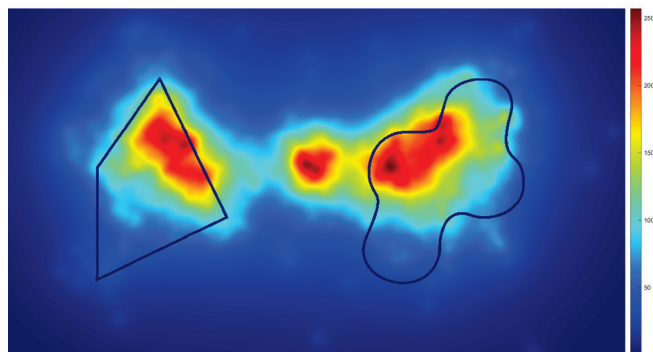


Figure 11 Thermal map of fixations of all participants in the second study sample

Fig. 12 shows the percentage of fixations at different thresholds for all participants in the second study sample.

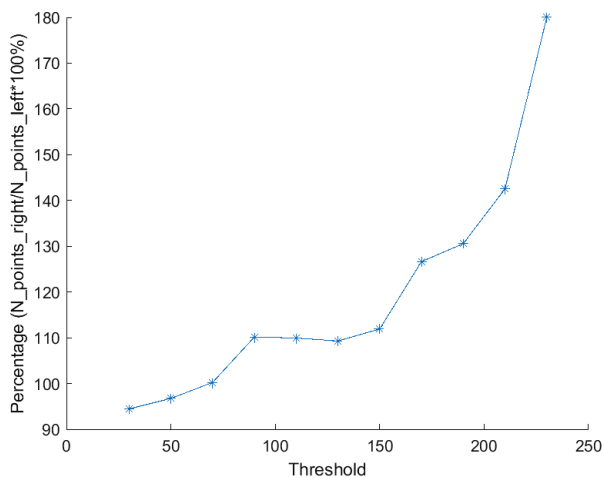


Figure 12 Percentage of fixations at different thresholds for all participants in the second study sample

It can be concluded that there is a statistically significant difference in the fixations of subjects between the organic and polygonal forms even with the replaced positions of shape observation, with the organic form showing a stronger effect. However, the fixation thresholds reveal that the right organic shape received more fixations at all measurement thresholds, except for the 50-fixation threshold at a single point.

5 CONCLUSION

This study paves the way for creating graphic and media communications tailored to the target audience, with scientifically validated parameters to select forms that minimize discomfort and instead evoke emotions such as happiness. Such messages are likely to be perceived more effectively by users.

From the initial analysis of a physical questionnaire, which was designed flexibly to encourage creativity rather than rigid responses, we observed a clear preference for organic two-dimensional shapes (68 %) over polygonal shapes (32 %). Most respondents indicated that organic forms evoked emotions of happiness and calmness, with many adding that these shapes brought them feelings of relaxation and pleasure. In contrast, polygonal shapes were most often associated with emotions such as fear, threat, and discomfort. Interestingly, even among respondents who favoured polygonal shapes, the predominant response was that these shapes instilled a sense of fear.

Statistical analysis of the experimental results confirmed the hypothesis that organic shapes have a stronger impact on visual perception than polygonal shapes in the context of graphic communications. Detailed visual analysis, supported by the fixation images from all respondents, further reinforces the conclusion that organic shapes are highly desirable in graphic and visual communication. These shapes tend to evoke emotions such as happiness and are likely to resonate innately with the target audience. This response may stem from our daily exposure to similar forms in nature, which are deeply embedded in our memory and thus more easily recognized and accepted.

The shapes we use in communication play a vital role in distinguishing products within the mass production landscape. By selecting the right forms, attention can be significantly enhanced, thereby increasing the visual appeal and overall attractiveness of graphic or multimedia products.

As communication becomes increasingly personalized, future research should explore shape preferences based on gender to identify differences in how men and women perceive organic and polygonal two-dimensional shapes. Expanding the scope, future studies could also examine the impact of colour on these shapes, exploring how individuals react to coloured organic and polygonal forms. Additionally, similar investigations should be conducted with 3D organic and polygonal shapes, focusing on their application in user interfaces and video game design.

6 REFERENCES

- [1] Bar, M. & Neta, M. (2006). Humans prefer curved visual objects. *Psychological Science*, 17(8), 645-648. <https://doi.org/10.1111/j.1467-9280.2006.01759.x>
- [2] Leder, H., Tinio, P. L. & Bar, M. (2011). Emotional valence modulates the preference for curved objects. *Perception*, vol 40, 649-655. <https://doi.org/10.1068/p6845>
- [3] Vusić, D., Geček, R. & Hajdek, K. (2016). Color appearance of the neon color spreading effect. *Acta graphica* 27(2), 7-13.

- [4] Marin, M., Mrvac, N., Vusić, D. (2009). *Vizualna psihofizika i dizajn*. Varaždin: Veleučilište u Varaždinu. (in Croatian)
- [5] Johnson, G. M. & Fairchild, M. D. (2003). *Visual psychophysics and color appearance*. CRC Press, Chapter in Digital Color Imaging Handbook.
<https://doi.org/10.1201/9781420041484.ch2>
- [6] Geček, R. (2021). *Determination of visual perception of organic and polygonal shapes in graphic communication processes*, Dissertation, Faculty of Graphic Arts, University of Zagreb. <https://urn.nsk.hr/urn:nbn:hr:216:217649> (in Croatian)
- [7] Leek, E. C., Cristino, F., Conlan, L. I., Patterson, C., Rodriguez, E. & Johnston, S. J. (2012). Eye movement patterns during the recognition of three-dimensional objects: Preferential fixation of concave surface curvature minima. *Journal of Vision*, 12(1):7, 1-15. <https://doi.org/10.1167/12.1.7>
- [8] Bierut, M., Drenttel, W. & Heller, S. (2002). *Looking Closer Four: Critical Writings on Graphic Design*. First Edition. New York: Allworth Press.
- [9] Landow, J., Ritchie, J. & Crooks, R. (2012). *Infographics: The Power of Visual Storytelling*. First Edition. New Jersey: John Wiley & Sons, Inc.
- [10] Stoklossa, U. (2007). *Advertising: New Techniques for Visual Deduction*. Second Edition. London: Thames & Hudson Ltd
- [11] Smiciklas, M. (2012). *The Power of Infographics: Using pictures to communicate and connect with your audiences*. First Edition. Indianapolis: Que Publishing.
- [12] Downs, S. (2011). *The Graphic Communication Handbook*. London: Routledge.
- [13] Resnic, E. (2003). *Design for Communication: Conceptual Graphic Design Basics*, Wiley.

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