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THE NATURAL AND ARTIFICIAL MANIFESTATIONS OF THE GOLDEN RATIO AND ITS IMPLICATIONS ON ASPECT RATIO

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Abstract

The ratio is a number that may be used to indicate one item as a proportion of another. Ratios are useful in a variety of applications such as structures and designs. The studies have revealed that there are many ratios of which some are natural manifestations, and some are established to construct a system or design structures. This study is meant to highlight the significance of some natural manifestations as well as other artificial implications of ratios and the implementation of the golden ratio in the aspect ratios.

Keywords : Golden Ratio; Golden Spiral; Fibonacci Sequence; Aspect Ratio; Paper Size; Golden Aspect Ratio.

I. INTRODUCTION

In the realm of natural and artificial design ratios have played an elegant role and have contemplated humans for in-depth study. The first of its kind is the Golden Ratio which is a natural manifestation implemented in artificial structures and designs. The implication of the adherence to this particular aesthetic ratio has resulted in the betterment of perception quantities beauty, balance, and harmony [1], [2], [7], [16].

The aspect ratio $\sqrt{2}:1$ used in the design of writing papers is implemented throughout the world except a few parts of America are represented by ISO 216 and ISO 269. The paper sizes are categorized into A, B, and C series [3], [4]. The appearance of the diamonds is determined by the Diamond proportions. The diamond proportions indicators are the ratios of the dimensions of width, depth, and the table of the crystal [5].

The modern television aspect ratio is another manifestation of the ratios which has made the television viewing of motion pictures a better experience. The aspect ratio 16:9 is equivalent to 1.77:1 and was first proposed in 1984. The international standard ISO 1223 describes the position and dimension of the maximum safe areas for 4:3 and 16:9 aspect ratios for television

transmissions [6].

II. DISCUSSION

A. Understanding Golden Ratio

The golden ratio is an aesthetic number that has manifested in many ways in nature. The golden ratio is expressed as the ratios of certain lengths of line segments 'P' and 'Q' given by

$$\frac{P}{Q} = \frac{P+Q}{P}$$

This ratio expresses self-symmetry with the value $\phi = 1.618$ approximated to three decimals. It is observed that any number in a Fibonacci sequence if divided by an immediate previous number results in the approximation of ϕ. It could also be verified that the higher the value of the number in the sequence smaller the approximation of ϕ which means the ratio is closer to the golden ratio [1].

B. Natural Manifestations of Golden Ratio

The manifestation of the golden ratio could be observed in various phenomena starting from the microscopic to the astronomical scale. The study conducted by Oldershaw [7] indicates the pitch angle of spiral galaxies yielding a golden spiral which is a special logarithmic spiral. It was also reported that the growth in the radius of the golden spiral is by a factor of ϕ. The study conducted by Boyadzhiev [8] reveals the spiral trajectory followed by an insect due to a point light source. The manifestation of the Fibonacci sequence is observed in the mean distances of the planets from the sun in the solar system. The periods of revolution of the satellites from the giant planets also follow closely the Fibonacci ratios [9].

The observations Heinen et. al. describe the manifestation of transverse dimensions of the left ventricle, annulus dimensions of the mitral valve, and the angle made by the inlet axis and the outflow tract axis of the right ventricle as the golden ratio. There was an observed departure from when the heart was not healthy for all three of these parameters [10]. This implies that such data might be used to detect when the heart deviates from normal. The literature also describes the manifestation of the golden ratio in the Brain, Face, Lips, Teeth, Protein and Amino Acids, Pen-rose Tailing and Quasi crystals, and atomic bond lengths [1], [11].

C. Artificial Manifestations of Golden Ratios

The golden ratio exhibits its implications in classical mechanics related to coupled oscillator problems as per the study [12]. The study reveals the appearance of the golden ratio when the symmetry is lost and also describes its appearance in normal modes of vibration. The study by Kazlacheva [13] describes the application of the golden ratio in fashion design and pattern making. The study concludes with the use of the golden ratio and Fibonacci sequence for creating beautiful and harmonic forms directly or by making geometrical figures. The study

[14] concludes the findings that the golden ratio helps to achieve technical balance and beauty through conventional proportionality. The applications of the golden ratio in structural design are a result of architects' judgment conforming to social demand and cultural thoughts.

The findings of Tanackov. et al. [15] reveals that the golden ratio phenomenon is a subset of Markovian processes. According to this study, the golden ratio domain suggests that artificial intelligence approaches are specific analytical branches of the golden ratio. The implications of study [16] describe Golden ratios implemented photos are more statistically preferred and visually appealing in comparison with Non-Golden Ratio implemented photos. However, the study also implies the implementation of a golden ratio in all layouts is not recommended.

D. Writing/Printing Paper Aspect Ratios

The documentation is classified into paper documentation and electronic documentation. Paper documentation requires various sizes of paper depending on the purposes like writing, billing paper, cards, posters, and printing documents. The International Organization for Standardization (ISO) has standardized writing or printing paper sizes using the metric system. ISO standardized the paper into three variants, A, B, and C-series. As per the ISO standards, the A-series papers range from A0 to A10, the B-series from B0 to B10, and the C-series from C0 to C10. The aspect ratio, the ratio of height to width, is $\sqrt{2}:1$ as per the ISO standards [3], [4]. Both ISO 216 and ISO 269 paper sizes (Except some envelopes) mention the same aspect ratio $\sqrt{2}:1$.

In particular, the relation between the width and height of a paper relates to each other the same as the side and the diagonal of a square. The aspect ratio is convenient and a bit amusing because, place two paper of ratio next to each other parallel to their height or when equivalently cut one parallel to its width into two halves, then the resulting paper will have the same aspect ratio or width to height ratio approximately equal to $\sqrt{2}:1$ with millimeter correction.

1) ANSI Series: Across the world, most countries implement ISO 216, ISO 217, and ISO 269 standards except North America, South America, parts of Central America, and Canada. Where North America, South America, parts of Central America and Canada use American National Standards Institute's (ANSI) such as "Letter", "Legal" and "Tabloid" instead of A4 and A5 (Table I).

TABLE I : ASPECT RATIO FOR ANSI PAPER SIZES

NAME	SIZE in cm		(Y/X) ratio	Area
	Width X	Height Y		
Letter	21.59	27.94	1.29	603.22
Tabloid	27.94	43.18	1.54	1206.44

Legal	21.59	35.56	1.65	767.74
Statement	13.97	21.59	1.54	301.61
Executive	18.42	26.67	1.45	491.26

2) ISO A-Series: The dimensions of the A-series paper are as defined by the ISO 216 standard. A-Series consists of eleven sizes designated A0–A10 (Table II), all of which have an aspect ratio of $\sqrt{2}:1$ [3]. The schematic of the series is in the Figure.1. The A4 standard has been adopted by all countries in the world except the United States and Canada. In Mexico, Costa Rica, Colombia, Venezuela, Chile, and the Philippines, the US letter format is still in common use, despite their official adoption of the ISO standard. The specification of tolerances as per ISO 216 is to produce A-series paper sizes are ±1.5mm up to 150mm, ±2mm from 150 mm to 600 mm, and ±3mm above 600 mm.

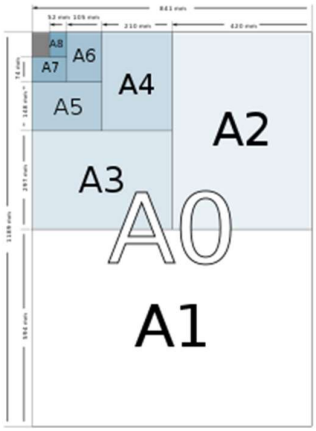

Fig. 1. A-series schematic diagram [17]

TABLE II : A-SERIES PAPERS DIMENSIONS

NAME	SIZE in mm		(Y/X) ratio	Area in cm^2
	Width X	Height Y		
A0	841	1189	1.41	9999.49
A1	595	841	1.41	5003.95
A2	420	594	1.41	2494.80
A3	297	420	1.41	1247.40
A4	210	297	1.41	623.70
A5	148	210	1.42	310.80
A6	105	148	1.41	155.40
A7	74	105	1.42	77.70
A8	52	74	1.42	38.48
A9	37	53	1.43	19.61
A10	26	37	1.42	9.62

3) ISO B-Series: The B-series paper sizes are presented in Table III and are less common than the A-series. The aspect ratio of B-series is the same as A-series [3]. However, the dimensions differ from those of the A-series. The area of B-series sheets is the geometric mean of successive A-series sheets. While less common in office use, the B-series is used for a variety of applications in which one A-series size would be too small, but the next A-series size is too large, or because they are convenient for a particular purpose. The B-series papers are broadly used in the printing industry to describe both paper sizes and printing press sizes, including digital presses. ISO 216 specifies tolerances that are similar to A-series.

TABLE III : B-SERIES PAPERS DIMENSIONS

NAME	SIZE in mm		(Y/X) ratio	Area in cm^2
	Width X	Height Y		
B0	1001	1414	1.41	14154.14
B1	707	1000	1.41	7070.00
B2	50	707	1.41	3535.00
B3	353	500	1.42	1765.00
B4	250	353	1.41	882.50
B5	176	250	1.42	440.00
B6	125	176	1.41	220.00
B7	88	125	1.42	110.00
B8	62	88	1.42	54.56
B9	44	62	1.41	27.28
B10	31	44	1.42	13.64

4) ISO C-Series: It is primarily used for envelopes. This envelope will hold the A-series paper of the same size unfolded. The C-series is defined in ISO 269 [4], which was withdrawn in 2009 without a replacement, but is still specified in several national standards. The area of C-series sheets is the geometric mean of the areas of the A and B series sheets of the same number. This envelope holds the A-series paper neatly unfolded. ISO 269:1985 specifies The deviations permissible on dimensions are ±1.5mm.

TABLE IV : C-SERIES PAPERS DIMENSIONS

NAME	SIZE in mm		(Y/X) ratio	Area in cm^2
	X	Y		
C0	917	1297	1.41	1189349.00
C1	648	917	1.42	594216.00
C2	458	648	1.41	296784.00
C3	324	458	1.41	148392.00
C4	229	324	1.41	74196.00
C5	162	229	1.41	37098.00
C6	114	162	1.42	18468.00
C7	81	114	1.41	9234.00

C8	57	81	1.42	4617.00
C9	40	57	1.43	2280.00
C10	28	40	1.43	1120.00

E. Modern Television Aspect Ratios

Stepping on technology has brought a change in the broadcasting the media at home has been at the forefront of technology over time. This is true when it comes to television screen sizes. In the 1920s General Electronics introduced a television with a 3-inches screen. Then, in the 1930s 8-inch screen was introduced by Emyvisor, in the 1940s 10-inches by RCA, in the 1950s 12.5-inches by Philco, in the 1960s 23-inches by Phillips, in the 1970s 25-inches by Zenith and in 1980s 35-inches by Mitsubishi then after TV screen evolved into various sizes.

Researchers have examined the influence of screen size on the number of viewer responses, including those related to attention, arousal, memory, evaluation, presence, and enjoyment of the media [18]. Other studies have shown that the viewing distance do matter for better media experience along with the screen size [19]. Images and video segments were played on two different screen sizes, i.e., 24-inches and 68-inches. Viewers paid more attention to larger screen sizes [18],[20]. This leads to a positive experience in media when it is on bigger screens. Thus, from the studies, the television screen size plays a vital role in grabbing the attention of the viewers for distinct reasons. When watching sports, movies, action, and while playing games on television, screen size makes a presence [21]. The whole environment feels real for those who are watching the movie, e.g., the car driven by the character and, the ornaments on a female character, are all seem to be real physical objects to the viewers, who are experiencing the movie environment. The whole game environment seemed to be real physical objects to the players, who control the avatar in the gaming environment. Physical presence is one of the key elements of the gaming experience and players can be so immersed in the gaming that they have the illusion that the gaming environment is real world [22].

ISO 1223:2003 [6] defines the position and dimensions of the maximum safe areas of the images on 16 mm and 35 mm motion–picture film, which are transmitted by television. It applies to all formats which are intended for use in either or both 4:3 and 16:9 aspect ratios. It is the international standard format for widescreen. It has become the most common aspect ratio for televisions, mobiles, and computer monitors, and is also the international standard image format for UHD, HDTV, Full HD,

TABLE V: MODERN TELEVISION MOTION PICTURE DIMENSIONS

Standard Size in inch	Width(W) in cm	Height(H) in cm	(W/H) ratio	Area cm²
32.00	70.90	39.90	1.78	2828.91
40.00	88.60	49.80	1.78	4412.28
43.00	95.30	53.60	1.78	5108.08
50.00	110.70	62.20	1.78	6885.54

55.00	121.70	68.60	1.77	8348.62
60.00	132.80	74.70	1.78	9920.16
65.00	144.00	81.00	1.78	11664.00
70.00	154.90	87.10	1.78	13491.79
75.00	166.10	93.50	1.78	15530.35
80.00	177.00	99.60	1.78	17629.20
85.00	188.20	105.90	1.78	19930.38

and SD digital television today. In this study aims to discuss 16:9 aspect ratios in television screens of different sizes. The standard television screen sizes and their dimensions are listed in the Table V.

III. IMPLICATIONS

A. Implications of the golden ratio in aspect ratio of paper sizes

Based on the discussion in the section II-C about artificial manifestations of the golden ratio, the implementations of the golden ratio resulting in the betterment of perception quantities beauty, balance, and harmony [1], [2], [7], [16], in this study the implications of golden ratio applied to the aspect ratio of papers is studied.

The following are the aspects of implementing the golden ratio in aspect ratio.

1) Golden Height: The Height Y of the paper is adjusted so that the ratio of height to width is equal to the Golden ratio by keeping Width X unaltered. The corresponding altered area of the paper is calculated.

2) Golden Width: The Width X of the paper is adjusted so that the ratio is equal to the Golden ratio by keeping Height Y unaltered. The corresponding altered area of the paper is calculated.

Altering the aspect ratio to implement the golden ratio either the height of the paper has to be increased or the width of the paper needs to be decreased. Thus, the writing and printing area changes. The calculations proposed for implementing the golden ratio in aspect ratio are given in the table VI.

B. Implications of the golden ratio in aspect ratio of Modern Television Motion Picture sizes

Standard television size ranging from 32 inches to 85 inches listed in the table follows a 16:9 aspect ratio or width-to-height ratio equal to 1.77778. The 16:9 aspect ratio with a width of 16 units and height of 9 units. This 16:9 aspect ratio enhances the quality of images by allowing for bolder backdrops and scenery, hence 16:9 aspect ratio is used while designing the television screen.

Further, to alter the aspect ratio to implement the golden ratio either the height of the picture has to be increased or the width of the picture needs to be decreased. Thus, the display area changes correspondingly. The calculations proposed for implementing the golden ratio in the aspect ratio of television are given in the table VII.

TABLE VI : PAPER GOLDEN ASPECT RATIO

NAME	SIZE in cm		(Y/X) ratio	Area	Golden Y	Golden Y Area	Golden X	Golden X Area
	Width X	Height Y						
Letter	21.59	27.94	1.29	603.22	34.93	754.20	17.27	482.47
Tabloid	27.94	43.18	1.55	1206.45	45.21	1263.08	26.69	1152.36
Legal	21.59	35.56	1.65	767.74	34.93	754.20	21.98	781.53
Statement	13.97	21.59	1.55	301.61	22.60	315.77	13.34	288.09
Executive	18.42	26.67	1.45	491.26	29.80	548.98	16.48	439.61
A0	84.10	118.90	1.41	9999.49	136.07	11443.81	73.49	8737.46
A1	59.50	84.10	1.41	5003.95	96.27	5728.13	51.98	4371.33
A2	42.00	59.40	1.41	2494.80	67.96	2854.15	36.71	2180.69
A3	29.70	42.00	1.41	1247.40	48.06	1427.22	25.96	1090.24
A4	21.00	29.70	1.41	623.70	33.98	713.54	18.36	545.17
A5	14.80	21.00	1.42	310.80	23.95	354.41	12.98	272.56
A6	10.50	14.80	1.41	155.40	16.99	178.39	9.15	135.38
A7	7.40	10.50	1.42	77.70	11.97	88.60	6.49	68.14
A8	5.20	7.40	1.42	38.48	8.41	43.75	4.57	33.84
A9	3.70	5.30	1.43	19.61	5.99	22.15	3.28	17.36
A10	2.60	3.70	1.42	9.62	4.21	10.94	2.29	8.46
B0	100.10	141.40	1.41	14154.14	161.96	16212.38	87.39	12357.21
B1	70.70	100.00	1.41	7070.00	114.39	8087.56	61.80	6180.47
B2	50.00	70.70	1.41	3535.00	80.90	4045.00	43.70	3089.30
B3	35.30	50.00	1.42	1765.00	57.12	2016.17	30.90	1545.12
B4	25.00	35.30	1.41	882.50	40.45	1011.25	21.82	770.14
B5	17.60	25.00	1.42	440.00	28.48	501.19	15.45	386.28
B6	12.50	17.60	1.41	220.00	20.23	252.81	10.88	191.45
B7	8.80	12.50	1.42	110.00	14.24	125.30	7.73	96.57
B8	6.20	8.80	1.42	54.56	10.03	62.20	5.44	47.86
B9	4.40	6.20	1.41	27.28	7.12	31.32	3.83	23.76
B10	3.10	4.40	1.42	13.64	5.02	15.55	2.72	11.97
C0	91.70	129.70	1.41	11893.49	148.37	13605.58	80.16	10396.84
C1	64.80	91.70	1.42	5942.16	104.85	6794.05	56.67	5197.09
C2	45.80	64.80	1.41	2967.84	74.10	3393.98	40.05	2595.20
C3	32.40	45.80	1.41	1483.92	52.42	1698.51	28.31	1296.44
C4	22.90	32.40	1.41	741.96	37.05	848.50	20.02	648.80
C5	16.20	22.90	1.41	370.98	26.21	424.63	14.15	324.11
C6	11.40	16.20	1.42	184.68	18.45	210.28	10.01	162.20
C7	8.10	11.40	1.41	92.34	13.11	106.16	7.05	80.32
C8	5.70	8.10	1.42	46.17	9.22	52.57	5.01	40.55
C9	4.00	5.70	1.43	22.80	6.47	25.89	3.52	20.08
C10	2.80	4.00	1.43	11.20	4.53	12.69	2.47	9.89

The new dimensions of Modern Television are determined by implementing the golden ratio for the aspect ratio. The golden aspect ratio could be obtained by either manipulating the "width" or "Height" named "Golden W" and "Golden H". Based on the new dimensions the golden diagonal of the television is calculated both for modifications in height and width. The deviations from the modern standard television sizes are calculated for both Golden W and Golden H. The Size Deviation plots are as mentioned in the figure.2.

IV. CONCLUSIONS

The studies have revealed that the incorporation of the golden ratio resulted in the betterment of perception quantities beauty, balance, and harmony. Thus, the study concludes that the Golden Aspect Ratio could be implemented in the aspect ratio of printing papers and television. It is observed that altering the width reduces the available aspect area and altering the height to the golden height increases the aspect area. In the case of modern television aspect ratio it is observed that, while altering the width and height to match the aspect of modern television with the golden ratio, altering the height has advantages as the deviation from the standard size is lesser when compared to altering the width.

TABLE VII : MODERN TELEVISION GOLDEN ASPECT RATIO

Standard TV Sizes and fitting it to Golden Ratio								
Standard Size inch	**Width(W) cm**	**Height(H) cm**	**(W/H) ratio**	**Area cm²**	**Golden (H) cm**	**Golden (H) area cm²**	**Golden (W) cm**	**Golden (W) area cm²**
32.00	70.90	39.90	1.78	2828.91	43.82	3106.80	64.56	2575.87
40.00	88.60	49.80	1.78	4412.28	54.76	4851.64	80.58	4012.71
43.00	95.30	53.60	1.78	5108.08	58.90	5613.16	86.72	4648.45
50.00	110.70	62.20	1.78	6885.54	68.42	7573.85	100.64	6259.78
55.00	121.70	68.60	1.77	8348.62	75.22	9153.83	110.99	7614.24
60.00	132.80	74.70	1.78	9920.16	82.08	10899.78	120.86	9028.59
65.00	144.00	81.00	1.78	11664.00	89.00	12815.82	131.06	10615.70
70.00	154.90	87.10	1.78	13491.79	95.74	14829.43	140.93	12274.81
75.00	166.10	93.50	1.78	15530.35	102.66	17051.43	151.28	14144.96
80.00	177.00	99.60	1.78	17629.20	109.39	19362.79	161.15	16050.82
85.00	188.20	105.90	1.78	19930.38	116.32	21890.75	171.35	18145.56

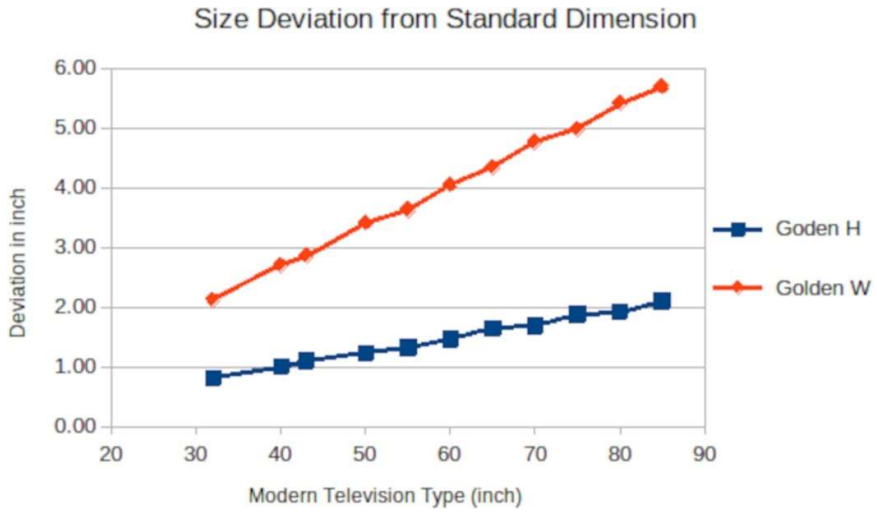

Fig. 2. Size Deviation from Standard Size

REFERENCES

[1] Callum Robert Marples, Philip Michael Williams, The Golden Ratio in Nature: A Tour across Length Scales, Symmetry 2022, 14, 2059. https://doi.org/10.3390/sym14102059

[2] Z I Kazlacheva, An investigation of application of the golden ratio and Fibonacci sequence in fashion design and pattern making, IOP Conf. Series: Materials Science and Engineering 254 (2017) 172013 doi:10.1088/1757-899X/254/17/172013

[3] ISO 216:2007(E),Writing paper and certain classes of printed matter — Trimmed sizes — A and B series, and indication of machine direction.

[4] ISO 269-1985(E), Correspondence envelopes — Designation and sizes.

[5] Diamond Cut: Anatomy of a Round Brilliant, GIA Education, January 14, 2016.

[6] ISO 1223:2003, Cinematography — Picture areas for motion-picture films for television — Position and dimensions.

[7] Oldershaw, R.L., The Preferred Pitch Angle of Spiral Galaxies; Mathematical and Physical Implications, Mon. Notes Astron. Soc. S.Afr. 1982, 41, 42. Provided by the SAO/NASA Astrophysics Data System.

[8] Boyadzhiev, K.N., Spirals and Conchospirals in the Flight of Insects,The Coll. Math. Journal 1999, 30, 23–31.

[9] O.W., Lombardi, M.A.,The Golden mean in the solar-system, Lombardi, Fibonacci Q. 1984, 22, 70–75.

[10] Henein, M.Y., Zhao, Y., Nicoll, R., Sun, L., Khir, A.W., Franklin, K., Lindqvist, P., The human heart: Application of the golden ratio and angle, Int. J. Cardiol. 2011, 150, 239–242.

[11] Tripuravaram V K Reddy, Sihivahanan Dhanasekaran, The Golden Proportion,Journal of Operative Dentistry and Endodontics, July-December 2017;2(2):79-83.

[12] M Moorman and John Eric Goff,Golden ratio in a coupled-oscillator problem Crystal, Eur. J. Phys. 28 (2007) 897–902.

[13] Z I Kazlacheva,An investigation of application of the golden ratio and Fibonacci sequence in fashion design and pattern making, IOP Conf. Series:

Materials Science and Engineering 254 (2017) 172013 doi:10.1088/1757-899X/254/17/172013

[14] Maysa Osman Khider, Architecture Development and Golden Ratio, International Journal of Science and Research, Volume 9 Issue 3, March 2020, DOI: 10.21275/SR20228105319

[15] Ilija Tanackov, Jovan T Milan Kostelac,The Golden Ratio in Probabalistic and Artificial Intelliigence, Tehni ki vjesnik cˇ 18, 4(2011) 641-647

[16] Adem Gjonbalaj, Daniel Olivo, Gwendolyn Lotter and Matthew Dalzell,The Golden Ratio and its Effects on the Perceived Visual Appeal of Photos,
Journal of Student Research, Volume 10 Issue 1 (2021),DOI: https://doi.org/10.47611/jsrhs.v10i1.1346

[17] https://en.wikipedia.org/wiki/Paper size

[18] Lombard, M., Ditton, T. B., Grabe, M. E., Reich, R. D. (1997),The role of screen size in viewer responses to television fare, Communication Reports, 10(1), 95–106. doi:10.1080/08934219709367663.

[19] Lund, A. M. (1993),The Influence of Video Image Size and Resolution on Viewing-Distance Preferences, , SMPTE Journal, 102(5), 406–415. doi:10.5594/j15915.

[20] Bridgeman, B., Lennon, M. L., Jackenthal, A. (2003),Effects of Screen Size, Screen Resolution, and Display Rate on Computer-Based Test Performance, Applied Measurement in Education, 16(3), 191–205. doi:10.1207/s15324818ame1603 2.

[21] Lombard, M., Reich, R., Grabe, M., Bracken, C., Ditton, Presence and television. Human Communication Research, T. (2000), 26(1), 75–98. doi:10.1111/j.1468-2958.2000.tb00750.x

[22] Hou, J., Nam, Y., Peng, W., Lee, K. M. (2012), Effects of screen size, viewing angle, and players' immersion tendencies on game experience. Computers in Human Behavior, 28(2), 617–623. doi:10.1016/j.chb.2011.11.007