ISSN: 2345-0479 / eISSN: 2345-0487

VILNIUS TECH
Vilnius Gediminas Technical University

CREATIVITY STUDIES

2024
Volume 17
Issue 1
Pages 14–26

https://doi.org/10.3846/cs.2024.16396

CREATIVE PROCESSES OF EMOTIONAL IMAGES: THE EFFECTS OF ASPECT RATIO ON THE EMOTIONAL AND AESTHETIC PROPERTIES OF IMAGES

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Article History:
- received 27 January 2022
- accepted 21 February 2023

Abstract. Proportions are one of the primary components of successful image composition during the visual art creation process, which, in turn, is determinant of the variety of effects of images on the viewer, including emotional reactions, attention, and aesthetic preference. The importance of image width and height ratio is especially visible in the current trend to adopt the widest possible screens in a variety of modern creative media applications: photo, video, computer games, *etc.* In the present study emotional and aesthetic evaluations of the three most popular aspect ratios that are used in digital media devices were compared. This was achieved by assessing emotional arousal and valence ratings together with the interest and appeal evaluations of realistic photos presented in 4:3, 16:9, and 21:9 aspect ratios. The results demonstrated that the widest images did not have an inherent advantage – photos presented in the mid-wide aspect ratio of 16:9 could be considered as more effective, because they were rated as evoking the most positive emotional reactions and as the most liked pictures. This demonstrated that single design features can have an independent emotional effect, which needs to be considered in visual design aiming to evoke emotional reactions to the viewer.

Keywords: aesthetics, aspect ratio, composition, creative process, design elements, emotion.

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1. Introduction

The emotional experience of viewers is a key element in many areas of research, education, business, or politics. Emotions are closely related with attitudes, behavior, and general well-being, so they are often the target of public service announcements, advertisements, architecture, therapy, and art. There is even a concept of emotional design, which is based on creating products that evoke positive emotions (Yu & Nagai, 2020). Emotions, evoked by physical products, such as physical work environment, can in turn stimulate creative processes for other products (Lin & Chang, 2020). However, to be able to effectively evoke a desired emotion by a product, the designer must understand the effects of different parts of a product. Only then this product will be effective as a marketing, motivation, entertainment, productivity, or therapy tool.

One important type of a creative product that can be applied in a variety of different areas is a visual image. Every image consists of many design elements, also known as image components or formal characteristics of images: color, size, shape, texture, object positioning, point of view, *etc.* In case of moving images (videos), additional elements become relevant (*e.g.*, timing, motion direction, speed, *etc.*). Each of these elements can have an individual

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effect on the viewer of the image. For example, it is well known that emotional reaction to a picture can be affected by manipulating color (Detenber et al., 2000; Gao & Xin, 2006; Polzella et al., 2005; Valdez & Mehrabian, 1994), size (Codispoti & de Cesarei, 2007; Detenber & Reeves, 1996; Lombard et al., 2000), shape (Aronoff et al., 1992; Larson et al., 2012; Lundqvist et al., 2004), complexity (Kuchinke et al., 2009), movement (Courtney et al., 2010; Detenber & Reeves, 1996; Detenber et al., 1998), and other characteristics of the image. Even more studies analyzed effects on aesthetic preference or likability (Belke et al., 2010; Cutting, 2006; McManus et al., 2011; Reber et al., 1998; Winkielman & Cacioppo, 2001). All these effects are a good demonstration why knowledge about single design elements can be a valuable tool when trying to achieve specific goals with a help of a visual stimulus. This can range from attention maintenance of a movie goer to a behavioral change of an advertisement observer or increased productivity in a work environment.

One of the most effective methods to control several design elements at the same time is using proper composition (McManus et al., 2011). This can be achieved either by moving the camera before taking a picture (framing) or selecting the usable area of an image after the capture (cropping). There are also possibilities to change composition during post-processing stage via such techniques as object movement or warping (Md Islam et al., 2017). However, in each of these cases an important consideration is the aspect ratio of an image. It can be described as relationship or proportion of width to height. While designers with a help of cropping, stretching, and resizing can use any aspect ratio, in practice three of them dominate (Zettl, 2011): 4:3, 16:9, 21:9. The ratio of 4:3 (1.33:1) is standard in photo industry (especially digital cameras) and is also the standard for analog television (TV) and legacy computer screen resolutions, such as video graphics array (VGA) connector, super VGA or extended graphics array. The ratio of 16:9 (5.33:3 or 1.75:1) is the current standard for modern digital TV, computer, or smartphone screens (with high-definition TV or 4K resolutions), while 21:9 (7:3 or 2.33:1) is becoming increasingly popular ratio for modern computer displays designed specifically for media consumption and is close to the most popular formats used in cinemas (2.35:1 and 1.85:1).

The defining feature of 4:3 ratio is that it is the closest to square, while still retaining the possibility of effective use of both landscape and portrait framing. The main advantage of wider aspect ratios is the greater immersion of the viewer due to a greater utilization of the viewer's peripheral vision, at the same time providing additional artistic means for the photo or video creators (*e.g.*, greater variety of ways to separate objects in a frame and convey motion, compared to more square-like ratios). In practice these three aspect ratios are being used interchangeably by resizing and applying black bars on top and bottom when necessary to fill the screen (letterboxing). A related method is to keep the original resolution of an image and instead of resizing just filling the bigger screen with black bars in all directions (pillarboxing). Nevertheless, to achieve the desired effects of an image, designer needs to take into consideration the final look of the image, in which aspect ratio plays a big role. Interestingly, despite the importance and the relative ease of manipulation of this design element, the research data is very limited on this subject. Moreover, while there are some data about the aspect ratios of rectangles (McManus et al., 2010), photo cropping (McManus et al., 2011) or framing (Cutting, 2015), these studies tend to concentrate on

preference assessments and exploratory research, so they neither distinguish particular compositions nor their exact emotional and aesthetic effects. It is universally agreed that photos can evoke emotional reactions. Even the whole databases of affective pictures, such as *International Affective Picture System* (Lang et al., 2008) or *Nencki Affective Picture System* (Marchewka et al., 2014), exist. However, while many authors (Brielmann & Pelli, 2019; Rolls, 2017) tend to regard aesthetic experience as almost equivalent to or at least very closely tied to any other emotional reaction, many other researchers (Frijda & Sundararajan, 2007; Scherer, 2004; Schindler et al., 2017) prefer a stricter separation of aesthetic (or A – artifact related) emotions from real-world (or R – represented world) emotions (Tan, 2000). The practical significance of such distinction is illustrated by the fact that aesthetic ratings of images depend on the expertise level of the raters – there are some data that people with an expertise in art tend to differ in their reactions to images compared to novice raters (McManus et al., 2011; Silvia, 2005). Interestingly, the difference between experts and nonexperts can remain even while assessing non-art stimuli, such as simple shapes (Vartanian et al., 2019). Furthermore, simple ratings of preference alone are subject to high variability due to individual differences (McManus et al., 2010), which are less visible in emotion ratings. Thus, while there is a strong connection between them, it is important to separate emotional and aesthetic effects to get a more accurate understanding of the role of different design elements of an image. This is critical when using that image for specific purposes, such as marketing or architecture, and intending to evoke a specific reaction in viewers, because the same feature of an image can be evaluated differently and have different effects, depending on whether aesthetic properties or real-life significance of an image is being assessed by the viewer (Tan, 2000). For example, a picture of a simple square is likely to evoke neutral emotional reactions to both a baker and a professional photographer, but the latter can experience positive reaction if the image adheres to artistic guidelines that were being taught at the design school. That is why current study attempts to separate personal relevancy based emotional reactions from stimulus connected aesthetic evaluations to provide data suitable for more varied applications.

Another issue is the fact that many previous studies that analyzed single design elements have used images with either abstract (*e.g.*, simple geometric shapes, Vartanian et al., 2019; Zentner, 2001) or artistic (*e.g.*, paintings, Belke et al., 2010; Polzella et al., 2005) content. While such stimuli have an important advantage by giving possibility to dissociate from the content effects, they still cannot be fully isolated from the effects of aesthetic evaluation (Gerger et al., 2014) and are relatively distant from many real-life applications in movies, TV shows, *YouTube* videos, news articles, *etc.* Of course, realistic images are not rare stimuli in psychological studies (Brielmann & Pelli, 2019; Detenber et al., 2000; Gerger et al., 2014; Marchewka et al., 2014), but it is less common to use them for studying aesthetic effects, especially while analyzing a variety of different aspect ratios.

That is why the main aim of the current study is to experimentally evaluate emotional and aesthetic effects of the most prevalent aspect ratios by using non-artificial stimuli that reflects images, used in the real world visual media.

2. Materials and methods

2.1. Participants

33 student volunteers (mean age 22.97, SD = 5.19, 23 females) participated in the study without any monetary reward. Recruitment process took place in the beginning or the end of university lectures (for psychology and law students) by one of the authors after receiving advance permission from the involved lecturers and getting the Ethics committee approval of the Institute of Psychology of Mykolas Romeris University (decision no. 01/-2020). To ensure motivation and ethical standards students were explicitly informed that they have the right to refuse to participate and could choose not to come to the laboratory, while still leaving the classroom (the experiment took place in the same university building, but a separate room from the classrooms). It was explained that by arriving to laboratory students provided their consent to participate in the study. Some students used the right to decline participation, so the mentioned final number of participants (33) is lower than the number of invited people. While this resulted in a relatively low sample size, this number was a good indication that participation was indeed voluntary. Moreover, comparable sample sizes were used in some other similar experiments, which used related analysis and found significant effects (*e.g.*, Briesemeister et al., 2012; Ueda et al., 2016).

Participants self-reported normal or corrected to normal vision and did not report any visual deficiencies. Vision was not measured separately, because most health conditions (*e.g.*, poor visual acuity or color blindness) would affect all stimuli equally.

2.2. Stimuli

42 photos (see Figure 1) were gathered using *Google Images*, selecting only images that are under a *Creative Commons* license, which provides the right to use, share, and modify them. Standardized affective picture sets, such as *International Affective Picture System* (Lang et al., 2008), *Nencki Affective Picture System* (Marchewka et al., 2014) or *Open Affective Standardized Image Set* (Kurdi et al., 2017), were not used, because they are limited to images in single aspect ratio (usually 4:3) only. Thus, standardized ratings are likely to become inaccurate if original photo is cropped to a different aspect ratio. Moreover, comparing different versions of aspect ratios of the same image might not be accurate, because they would not be equivalent based on composition and object placement. Aesthetic intentions of the photographer would also be changed in the modified versions.

The three aspect ratios (4:3, 16:9, 21:9) were selected to represent most used image proportions in photography, television, cinema, and computer design. Other popular aspect ratios 3:2, 6:7, 1:1 that are used in professional photography were not used in the current study, since they are less prevalent in consumer usage. Each of the three studied aspect ratios were represented by different photos to avoid the habituation effect due repeating almost identical stimuli and the negative effects of cropping and changing the original composition (that would be unavoidable when differently cropping the same original photo). However, the topic and general visual characteristics of the photos were balanced out. The main criterion for image selection was the variety of content, which had to represent the topics most

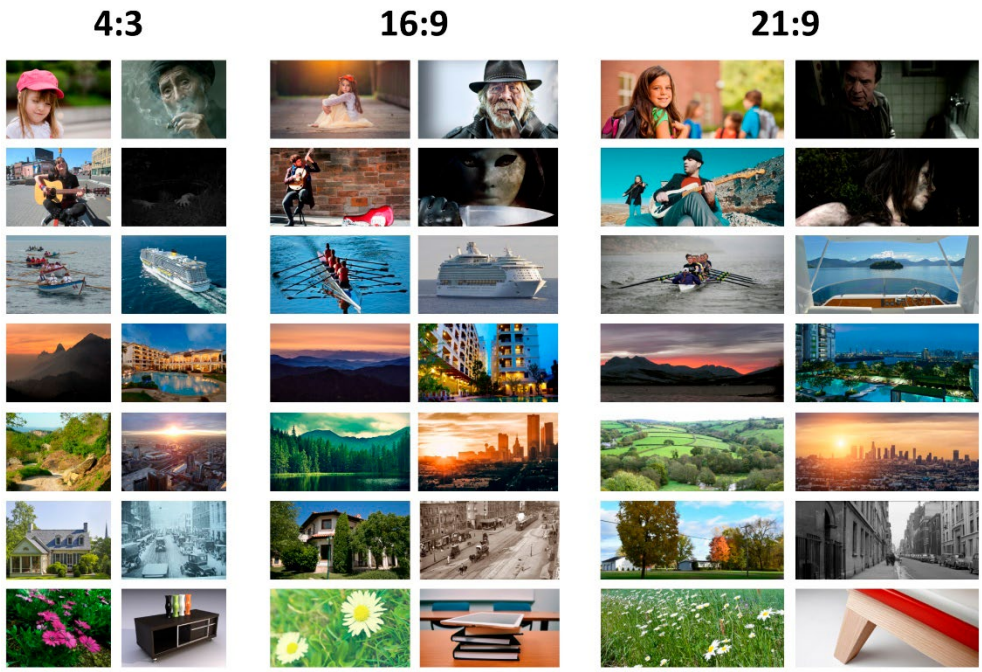


Figure 1. Experimental stimuli used in the study (source: created by authors)

commonly seen in different sources of visual media: nature and city landscapes, portraits, travel, sports, music performances, and simple objects, such as books or furniture. Photos with excessive empty space were avoided to maintain composition that utilizes selected aspect ratio as much as possible. All pictures were presented in three different aspect ratios (4:3, 16:9, 21:9) in such a way that each type of content would be equally represented in each aspect ratio (*e.g.*, there were an equal number of static people closeups with the same facial expression, composed in a similar fashion, and with a similar color scheme presented in every aspect ratio). Thus, while the content of each image was different to control participants' attention and fatigue, other image elements were controlled. However, some variability in depicted object properties, brightness, contrast, color, and other image characteristics was still present due to limited availability of photos that would conform to content requirements. Nevertheless, the effects of individual design elements were controlled by spreading out the variety in the characteristics of specific elements between different categories.

To maintain the same level of detail (that is directly related to image resolution) and limit the number of stimuli that would be required to maintain equivalency between different aspect ratios, physical image height was the same for all images (14.25° of visual angle) and aspect ratio was manipulated by varying the width only. Images were presented in the following resolutions: 1024x768 (4:3 ratio), 1366x768 (16:9 ratio), 1792x768 (21:9 ratio).

All images were presented in landscape position on a black background (to mimic the presentation of images on different aspect ratio screens, at the same time minimizing the effects of black bezels of the monitor used for the experiment) on a 23 inch 1920x1080 resolution,

51x29 cm size (16:9 aspect ratio) computer screen connected to a *Microsoft Windows* computer. Participants were seated at 80 cm distance from the screen and were observing image with both eyes. However, participant's head was not fixed to avoid incidental emotional effects, thus, the actual distance between eyes and the screen could vary somewhat.

2.3. Measures

The main dependent variables in this study were the subjective evaluations of personal emotional reactions and images themselves. That is why special rating scales were created by the authors based on the most frequently analyzed relations between different components of aesthetical experience (Berlyne, 1972; Brielmann & Pelli, 2019; Menninghaus et al., 2019; Rolls, 2017; Silvia, 2005). The goal was to ensure differentiation between the evoked emotional reaction on the viewer, limiting it to arousal and valence dimensions (regarding this as the representation of the emotional effect of an image), and the aesthetic properties of the stimuli, limiting them to interest and appeal dimensions (considering this as the representation of the aesthetic effect of an image). Evaluations were performed by using four bipolar scales. Each of them had 9 unnumbered ticks with two labels at the opposite ends of the scale as anchors (see Figure 2). All labels were presented in Lithuanian language.

At first participants had to measure their emotional reactions evoked by the presented image (participants were specifically instructed to rate their own current emotional reactions instead of emotions that might be depicted in a picture). This was done by using two separate scales titled *Evoked Emotion*: one for rating evoked emotional arousal (presented with the labels *Weak* and *Strong* at the opposite sides of the scale) and the other for rating evoked emotional pleasure (presented with labels *Unpleasant* and *Pleasant*).

After that, participants evaluated the image itself. This was performed by using two scales titled *Shown Picture*: one for measuring image's potential to attract attention (presented with the labels *Uninteresting* and *Interesting*) and the other for rating the general appeal of the presented image (presented with labels *Dislike* and *Like*). Scale titles and labels were selected to ensure that participants were using scales to rate different properties of images, most important ones being that the first two scales for each photo evaluated images' property to evoke emotional reactions on the viewer, while the last two scales evaluated the pictures' aesthetic properties. This distinction was emphasized during the instruction phase.

2.4. Procedure

Participants were first verbally informed about the general goal of the study (effects of pictures on the viewers) and possible uses of the results (emphasizing practical usage in visual media, including news, movies, and advertisements), without specifying which specific properties of images would be assessed. Then instruction about the procedure of the study was provided with the main task described on computer screen (presented in Lithuanian):

> "You will have to evaluate presented pictures and emotions evoked by them. Do that by using scales under a picture. First, evaluate how STRONG EMOTIONS were evoked by a picture. Then evaluate how PLEASANT EMOTIONS were evoked by a picture. After that evaluate how INTERESTING is the picture. Lastly, evaluate how much you LIKE the picture".

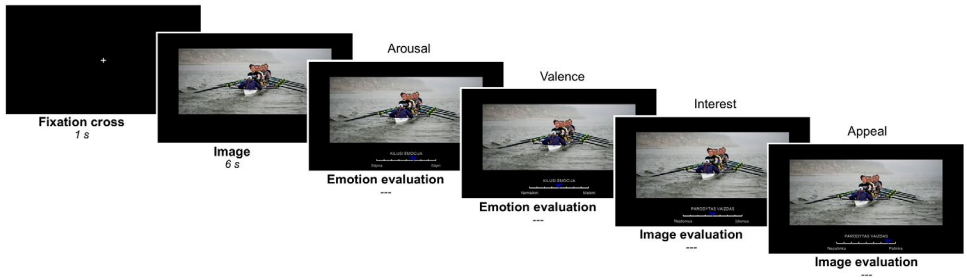
Then participants performed a sample trial with a test stimulus (it was an additional photo, which was not included in the analysis of data). After that, participants were provided an opportunity to get answers to any additional questions. Only after ensuring that participants fully understood the evaluation process the main experiment procedure began (see Figure 2).

Every trial started with a white fixation cross presented in the center of the black screen for 1 second. Then, an image appeared for 6 seconds, during which participants could look at an image unrestricted. After that, while the image was still visible (to avoid memory effects), rating scales appeared on the same screen one by one under the picture. Photos were presented in random order, but the rating scales were always presented in the same sequence: emotional arousal, emotional valence, image interest, image appeal. Such presentation (both separation of individual scales and keeping the scale presentation order constant) was selected to avoid probable participant confusion related to randomizing the order of presentation of scales. This was important for ensuring a more accurate differentiation between different ratings, especially distinction between the emotional reaction evaluation and the evaluation of an image. Naturally, such decision carries a risk of introducing sequence effects and possible association of different rating scales, but the same dangers also apply when presenting all four scales at the same time.

The rating time was not limited. After the last scale was rated the fixation cross was presented and a new trial began. No additional interstimulus interval was used due to maintained presentation of images. Each participant saw all images (every stimulus was presented only once) – a total of 42 trials.

The total duration of an experiment for one participant was around 40 minutes (the exact time depended on individual speed of participants). Presentation of stimuli was controlled by the open source *PsychoPy 1.85.6* software (Peirce, 2009; Peirce et al., 2019) running on a *Microsoft Windows* computer. Participants responded by using a wired mouse connected to the same computer. The use of a standard computer hardware was chosen, because it is adequate for the stimuli presentation and response gathering accuracy (independent variable was static image aspect ratio, while dependent variable – time-unlimited ratings), and allows ensuring equipment familiarity for the participants.

After completing the experiment each participant received a small gift in a form of a pencil with a laboratory logo.



Note: see text description in section 1.3 for scale label details.

Figure 2. The experimental design of the image presentation and rating procedure (source: created by authors)

2.5. Data analysis

Multiple repeated-measures analysis of variance (ANOVA) were computed for each of the following variables: emotional arousal ratings, emotional valence ratings, image interest ratings, and image appeal ratings. Values for each variable could range from 1 to 9. Higher value of the ratings represents higher arousal, higher pleasure, higher interest in an image, higher liking of an image, respectively. To determine more accurate effects Bonferroni *post hoc* test was used for pairwise comparisons, but Cohen's *d* effect size value was also calculated to provide more standard information. Data normality was confirmed both by visual inspection and Shapiro–Wilk test. The alpha level for significance was set at $p < .05$.

3. Results

Comparison of images presented in three different aspect ratios (4:3, 16:9, 21:9) did not show any significant differences in the arousal of evoked emotions: $F(2.64) = 0.74$, $MSE = .09$, $p = .48$, $\eta_p^2 = .02$.

Nevertheless, it was observed that width/height proportions had a significant effect on emotional valence: $F(2.64) = 5.2$, $MSE = .73$, $p = .008$, $\eta_p^2 = .14$. Pairwise comparisons revealed that the most positive emotional reactions were evoked by the mid-wide (16:9) images. They were rated as evoking significantly more positive ($M_{16:9} = 6.1$, $SD_{16:9} = .11$) emotional reactions compared to images based on standard ($M_{4:3} = 5.81$, $SD_{4:3} = .66$, $p = .015$, $d = .44$) or ultra-wide ($M_{21:9} = 5.88$, $SD_{21:9} = .63$, $p = .048$, $d = .34$) aspect ratios. There was no significant difference between standard (4:3) and ultra-wide (21:9) aspect ratios ($p = 1$).

Similar significant difference was revealed while comparing the ratings of how much participants liked the image: $F(2.64) = 6.07$, $MSE = .83$, $p = .004$, $\eta_p^2 = .16$. Pairwise comparisons demonstrated that the most liked images were based on the mid-wide (16:9) aspect ratio. They were rated by participants as more likable ($M_{16:9} = 6.1$, $SD_{16:9} = .71$) than photos that were based on standard ($M_{4:3} = 5.85$, $SD_{4:3} = .76$, $p = .013$, $d = .34$) or ultra-wide ($M_{21:9} = 5.87$, $SD_{21:9} = .8$, $p = .005$, $d = .35$) aspect ratios. There was no significant difference between standard (4:3) and ultra-wide (21:9) aspect ratios ($p = 1$). There were also no significant differences between different aspect ratios while comparing the evaluations of how interesting the image was: $F(2,64) = 2.11$, $MSE = .3$, $p = .13$, $\eta_p^2 = .06$.

Graphical representation of the results is presented in Figure 3.

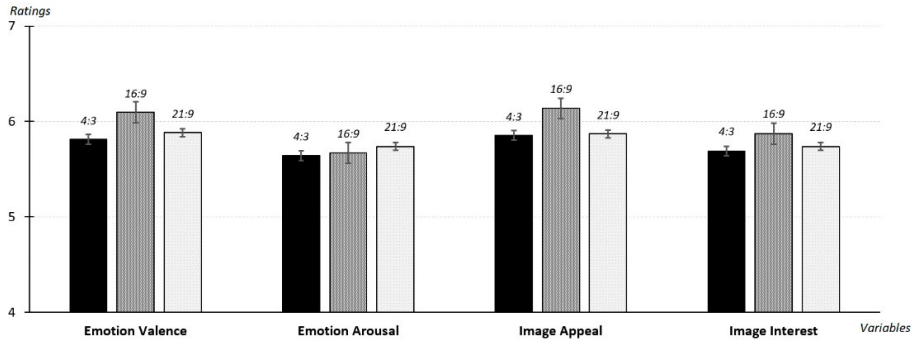


Figure 3. The mean ratings of participants' emotions and images themselves while viewing images presented in different aspect ratios (source: created by authors)

Since results were mirrored between emotional valence and image appeal, as well as between emotional arousal and image interest, possible relation between variables was assessed. For that the ratings of each image were averaged across all participants and Pearson correlation coefficient was calculated between all variables. Results revealed that there were strong positive correlations between all four ratings. That could hint about possible conflation effects while assessing different scales one after another. Nevertheless, aforementioned ANOVA results have demonstrated a significant distinction of 16:9 aspect ratio compared to other studied image proportions.

4. Discussion

While exploring the effects of different image proportions present study attempted to differentiate the evaluation of viewers' emotional reactions (their valence and arousal) and aesthetic properties of images (their interest and appeal). That is why it is important to discuss whether this differentiation was successful. The data showed strong positive correlations between all four variables, including the positive correlation between the valence of emotional reaction evoked by an image and the aesthetic appeal of this image. This supports theories, proposing a close link between emotional reactions and aesthetic value (Brielmann & Pelli, 2019; Rolls, 2017; Gerger et al., 2014; Xenakis et al., 2012), as opposed to the ideas discussing the possible distinction of utilitarian and aesthetic emotions (Frijda & Sundararajan, 2007; Scherer, 2004; Schindler et al., 2017; Tan, 2000). The same is true regarding the link between emotional arousal and aesthetic interest. Strong positive correlation between these two concepts could simply demonstrate that classic Berlyne's (1972) ideas about the inverted U-shaped relation between arousal and aesthetic pleasure are outdated. However, at the same time all these correlations could also mean that, despite the safeguards that were applied, participants failed to see the difference between emotional pleasure effects of images and aesthetic appeal (likability or beauty) effect of images. Current study was based around dimensional approach to emotions with the emphasis on the separation of personal emotional experience and aesthetic image evaluation. Perhaps such distinction of the source of experience was not enough and discrete approach to emotions emphasizing specific emotions, such as "happiness", "surprise", "awe", *etc.* (*e.g.*, Tan, 2000), would be more successful in making an accurate distinction of different experiences while observing different photos. Nevertheless, current study demonstrated a clear effect of image proportions – images based on mid-wide (16:9) aspect ratio received ratings showing higher emotional pleasure and aesthetic appeal compared to standard (4:3) and ultra-wide (21:9) aspect ratios. This significant finding is highly relevant not only for image composition purposes, but also for other practical uses, such as media selection, because it can facilitate decisions related to, for example, choosing a screen, which would evoke more positive effects on the viewer. This might be important for both professionals and consumers, especially considering that the general rule is to prioritize wider screens. Our experiment demonstrated that mid-wide can actually be better.

The observed distinction of 16:9 aspect ratio can be explained in several ways. One possible explanation are basic composition principles, such as golden ratio (also known as golden section). It is a ratio of longer part of an object compared to a shorter one, which is

approximately 1.618. That is very close to 1.75 – a ratio, which characterizes 16:9 wide format. However, previous research failed to find clear effects of the Golden ratio (McManus et al., 2010), so other explanations are more likely.

Relatively high emotional pleasure and image appeal ratings of 16:9 aspect ratio images could also demonstrate familiarity effect – this aspect ratio is the most common in modern media compared to other studied ratios, so it could evoke more positive emotions simply due to the mere exposure or prototypicality (Cutting, 2006). At the same time increased familiarity could also facilitate the processing of images and the increased fluency of cognitive processing is associated with positive aesthetic evaluations (Belke et al., 2010; Menninghaus et al., 2019; Reber et al., 1998; Winkielman & Cacioppo, 2001). Cognitive processing could also be facilitated by the possible congruence between an image and the screen in which this image was presented – 16:9 aspect ratio of images coincides with the proportions of the computer screen that was used in the study (also 16:9) and was identical for all participants. Such findings of possible interplay between screen and image aspect ratios is highly important for real-life media applications, since visual material is usually being prepared for consumption on a wide variety of screens and discrepancy between resolutions is usually being solved by applying black borders – the same way as was done in the present study (all three researched aspect ratios were presented in a way that there would still be black background visible in all directions, none of the images was presented full screen). This corresponds to a real-life consumption of media, especially considering that most screens are currently manufactured in wide (16:9) proportions and the popular media platforms, such as *YouTube*, *Netflix*, *etc.*, emphasize wide-screen friendly resolutions. This is even more significant for advertisements or illustrative photos and videos in news portals, which are usually limited only to a relatively small amount of screen real estate. So, it would be useful for future studies to research different aspect ratios further by using different screens.

Future studies could also evaluate possible effects of previous experience with aspect ratios. While all participants of the current study were psychology or law students, data about their hobbies or aspect ratios of their most frequently used personal smartphone or monitor screens were not collected, although could still be a factor.

Another feature of current study was that head movement of participants was not restricted during the experiment to avoid emotional effects of restriction itself that could be more observable than effects of the individual design element. However, such head fixation or head tracking could be useful in combination with eye-movement data to assess the role of eye movements on emotional effects of different aspect ratios. Observing ultra-wide (21:9) image is likely related with more eye and head movements compared to less wide images, thus, possibly, affecting cognitive processing and affective evaluations.

Lastly, current study concentrated on a single feature of composition – aspect ratio. Other factors (color, complexity, location of objects in the image, *etc.*) could still be at play. That is why the influence of other design elements should not be forgotten while applying current results. Even though image content was selected to be as equivalent for each aspect ratio as possible, it can be argued that remaining differences between images can still be significant. This was required to maintain a realistic nature of stimuli, because artists usually compose content based on a specific aspect ratio. Thus, additional data from studies with different

stimuli would be very valuable. Similarly, inclusion of additional measure evaluating cognitive processing fluency, preferably separately fluency and disfluency (Menninghaus et al., 2019) would provide a greater support for our discussion about the link between image processing and the reaction to it. Nevertheless, even though the content and other characteristics of images varied and could have their own independent effects on participants, the current study demonstrated that images characterized by 16:9 aspect ratio stood out from their counterparts in 4:3 and 21:9 aspect ratios. Thus, even though the exact reasons of the uniqueness of 16:9 aspect ratio are still open for discussion, current results have clearly demonstrated that the widest aspect ratio does not automatically provide the greatest impact on the viewer – there is an optimal aspect ratio for image presentation. This was observable despite variability in content and possible individual differences of participants.

5. Conclusions

The results of the study confirmed that image aspect ratio is indeed a significant variable affecting how the viewer will be influenced by a specific image. It was identified that mid-wide (16:9) aspect ratio has the potential to evoke the most positive emotional reaction, and images based on this ratio tend to be liked more.

Naturally, aspect ratio is not the only variable that determines emotions evoked by the image. Other design elements, such as color or shape, and also the content of an image also play a significant role. Culture, individual experiences, and other factors are still important. Thus, the fact that the whole is greater than the sum of its parts still remains true.

However, current findings have a significant practical value by revealing a specific effect of a specific design element. This knowledge, combined with the previous and future findings about other individual design elements, allow more purposeful creative process that leads to creative products that can reach their goals more effectively. A good illustration of this can be artificial intelligence based automatic processing of images or deliberate designer's decisions during image creation process. This is not limited to images that evoke positive emotions. The use of unexpected elements can be deliberate to achieve a shock effect that can be very useful in such contexts as advertising (Skorupa, 2014). Even though shocking advertisements tend to be based on shocking content, a similar effect is likely to be achievable by manipulating design elements alone (and, thus, avoiding dangers related to inappropriate content). However, to achieve similar goals the understanding of the effects of individual design elements is crucial.

References

Aronoff, J., Woike, B. A., & Hyman, L. M. (1992). Which are the stimuli in facial displays of anger and happiness? Configural bases of emotion recognition. *Journal of Personality and Social Psychology*, *62*(6), 1050–1066. https://doi.org/10.1037/0022-3514.62.6.1050

Belke, B., Leder, H., Strobach, T., & Carbon, C.-C. (2010). Cognitive fluency: High-Level processing dynamics in art appreciation. *Psychology of Aesthetics*, *Creativity*, *and the Arts*, *4*(4), 214–222. https://doi.org/10.1037/a0019648

Berlyne, D. E. (1972). Ends and means of experimental aesthetics. *Canadian Journal of Psychology*, *26*(4), 303–325. https://doi.org/10.1037/h0082439

Brielmann, A. A., & Pelli, D. G. (2019). Intense beauty requires intense pleasure. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.02420

Briesemeister, B. B., Kuchinke, L., & Jacobs, A. M. (2012). Emotional valence: A bipolar continuum or two independent dimensions? *SAGE Open*, *2*(4). https://doi.org/10.1177/2158244012466558

Codispoti, M., & Cesarei, de A. (2007). Arousal and attention: Picture size and emotional reactions. *Psychophysiology*, *44*(5), 680–686. https://doi.org/10.1111/j.1469-8986.2007.00545.x

Courtney, Ch. G., Dawson, M. E., Schell, A. M., Iyer, A., & Parsons, Th. D. (2010). Better than the real thing: Eliciting fear with moving and static computer-generated stimuli. *International Journal of Psychophysiology*, *78*(2), 107–114. https://doi.org/10.1016/j.ijpsycho.2010.06.028

Cutting, J. E. (2015). The framing of characters in popular movies. *Art and Perception*, *3*, 191–212. https://doi.org/10.1163/22134913-00002031

Cutting, J. E. (2006). The mere exposure effect and aesthetic preference. In P. Locher, C. Martindale, & L. Dorfman (Eds.), *Foundations and Frontiers in Aesthetics. New directions in aesthetics, creativity, and the arts* (pp. 33–46). C. Martindale & A. Berleant (Series Eds.). Baywood Publishing Company, Inc.

Detenber, B. H., & Reeves, B. (1996). A bio-informational theory of emotion: Motion and image size effects on viewers. *Journal of Communication*, *46*(3), 66–84. https://doi.org/10.1111/j.1460-2466.1996.tb01489.x

Detenber, B. H., Simons, R. F., & Bennett Jr., G. G. (1998). *Roll 'em!*: The effects of picture motion on emotional responses. *Journal of Broadcasting and Electronic Media*, *42*(1), 113–127. https://doi.org/10.1080/08838159809364437

Detenber, B. H., Simons, R. F., & Reiss, J. E. (2000). The emotional significance of color in television presentations. *Media Psychology*, *2*(4), 331–355. https://doi.org/10.1207/S1532785XMEP0204_02

Frijda, N. H., & Sundararajan, L. (2007). Emotion refinement: A theory inspired by Chinese poetics. *Perspectives on Psychological Science*, *2*(3), 227–241. https://doi.org/10.1111/j.1745-6916.2007.00042.x

Gao, X.-P., & Xin, J. H. (2006). Investigation of human's emotional responses on colors. *Color: Research and Application*, *31*(5), 411–417. https://doi.org/10.1002/col.20246

Gerger, G., Leder, H., & Kremer, A. (2014). Context effects on emotional and aesthetic evaluations of artworks and *IAPS* pictures. *Acta Psychologica*, *151*, 174–183. https://doi.org/10.1016/j.actpsy.2014.06.008

Islam, Md B., Lai-Kuan, W., & Chee-Onn, W. (2017). A survey of aesthetics-driven image recomposition. *Multimedia Tools and Applications*, *76*, 9517–9542. https://doi.org/10.1007/s11042-016-3561-5

Kuchinke, L., Trapp, S., Jacobs, A. M., & Leder, H. (2009). Pupillary responses in art appreciation: Effects of aesthetic emotions. *Psychology of Aesthetics, Creativity, and the Arts*, *3*(3), 156–163. https://doi.org/10.1037/a0014464

Kurdi, B., Lozano, Sh., & Banaji, M. R. (2017). Introducing the open affective standardized image set (OASIS). *Behavior Research Methods*, *49*, 457–470. https://doi.org/10.3758/s13428-016-0715-3

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). *International affective picture system* (*IAPS): Affective ratings of pictures and instruction manual*. Technical Report A-8. University of Florida, Gainesville, Florida, United States. https://gitlab.pavlovia.org/rsaitov/experimental-psycholoy-ltu-final/raw/563e2b213be7eb54829116f05b83f0124362d71b/IAPS.TechManual.1-20.2008(1).pdf

Larson, Ch. L., Aronoff, J., & Steuer, E. L. (2012). Simple geometric shapes are implicitly associated with affective value. *Motivation and Emotion*, *36*, 404–413. https://doi.org/10.1007/s11031-011-9249-2

Lin, S.-Y., & Chang, H.-I. (2020). Does open-plan office environment support creativity? The mediating role of activated positive mood. *Creativity Studies*, *13*(1), 1–20. https://doi.org/10.3846/cs.2020.10332

Lombard, M., Reich, R. D., Grabe, M. E., Bracken, Ch. C., & Bolmarcich Ditton, Th. (2000). Presence and television: The role of screen size. *Human Communication Research*, *26*(1), 75–98. https://doi.org/10.1111/j.1468-2958.2000.tb00750.x

Lundqvist, D., Esteves, F., & Öhman, A. (2004). The face of wrath: The role of features and configurations in conveying social threat. *Cognition and Emotion*, *18*(2), 161–182. https://doi.org/10.1080/02699930244000453

Marchewka, A., Żurawski, Ł., Jednoróg, K., & Grabowska, A. (2014). The Nencki affective picture system (NAPS): Introduction to a novel, standardized, wide-range, high-quality, realistic picture database. *Behavior Research Methods*, *46*, 596–610. https://doi.org/10.3758/s13428-013-0379-1

McManus, I. Ch., Cook, R., & Hunt, A. (2010). Beyond the golden section and normative aesthetics: Why do individuals differ so much in their aesthetic preferences for rectangles? *Psychology of Aesthetics, Creativity, and the Arts*, *4*(2), 113–126. https://doi.org/10.1037/a0017316

McManus, I. Ch., Zhou, F. A., l'Anson, S., Waterfield, L., Stöver, K., & Cook, R. (2011). The psychometrics of photographic cropping: The influence of colour, meaning, and expertise. *Perception*, *40*(3), 332–357. https://doi.org/10.1068/p6700

Menninghaus, W., Wagner, V., Wassiliwizky, E., Schindler, I., Hanich, J., Jacobsen, T., & Koelsch, S. (2019). What are aesthetic emotions? *Psychological Review*, *126*(2), 171–195. https://doi.org/10.1037/rev0000135

Peirce, J. W. (2009). Generating stimuli for neuroscience using *PsychoPy*. *Frontiers in Neuroinformatics*, *2*. https://doi.org/10.3389/neuro.11.010.2008

Peirce, J., Gray, J. R., Simpson, S., MacAskill, M., Höchenberger, R., Sogo, H., Kastman, E., & Lindeløv, J. K. (2019). *PsychoPy2*: Experiments in behavior made easy. *Behavior Research Methods*, *51*, 195–203. https://doi.org/10.3758/s13428-018-01193-y

Polzella, D. J., Hammar, S. H., & Hinkle, Ch. W. (2005). The effect of color on viewers' ratings of paintings. *Empirical Studies of the Arts*, *23*(2), 153–163. https://doi.org/10.2190/ECK9-C18E-RQN9-7WNE

Reber, R., Winkielman, P., & Schwarz, N. (1998). Effects of perceptual fluency on affective judgments. *Psychological Science*, *9*(1), 45–48. https://doi.org/10.1111/1467-9280.00008

Rolls, E. T. (2017). Neurobiological foundations of aesthetics and art. *New Ideas in Psychology*, *47*, 121–135. https://doi.org/10.1016/j.newideapsych.2017.03.005

Scherer, K. R. (2004). Which emotions can be induced by music? What are the underlying mechanisms? And how can we measure them? *Journal of New Music Research*, *33*(3), 239–251. https://doi.org/10.1080/0929821042000317822

Schindler, I., Hosoya, G., Menninghaus, W., Beermann, U., Wagner, V., Eid, M., & Scherer, K. R. (2017). Measuring aesthetic emotions: A review of the literature and a new assessment tool. *PloS ONE*, *12*(6). https://doi.org/10.1371/journal.pone.0178899

Silvia, P. J. (2005). Emotional responses to art: From collation and arousal to cognition and emotion. *Review of General Psychology*, *9*(4), 342–357. https://doi.org/10.1037/1089-2680.9.4.342

Skorupa, P. (2014). Shocking contents in social and commercial advertising. *Creativity Studies*, *7*(2), 69–81. https://doi.org/10.3846/23450479.2014.997317

Tan, E. S. (2000). Emotion, art and the humanities. In M. Lewis & J. M. Haviland-Jones (Eds.), *Handbook of emotions* (pp. 116–136). New York.

Ueda, R., Kuraguchi, K., & Ashida, H. (2016). Asymmetric effect of expression intensity on evaluations of facial attractiveness. *SAGE Open*, *6*(4). https://doi.org/10.1177/2158244016677569

Valdez, P., & Mehrabian, A. (1994). Effects of color on emotions. *Journal of Experimental Psychology: General*, *123*(4), 394–409. https://doi.org/10.1037/0096-3445.123.4.394

Vartanian, O., Navarrete, G., Chatterjee, A., Fich, L. B., Leder, H., Modroño, C., Rostrup, N., Skov, M., Corradi, G., & Nadal, M. (2019). Preference for curvilinear contour in interior architectural spaces: Evidence from experts and nonexperts. *Psychology of Aesthetics, Creativity, and the Arts*, *13*(1), 110–116. https://doi.org/10.1037/aca0000150

Winkielman, P., & Cacioppo, J. T. (2001). Mind at ease puts a smile on the face: Psychophysiological evidence that processing facilitation elicits positive affect. *Journal of Personality and Social Psychology*, *81*(6), 989–1000. https://doi.org/10.1037/0022-3514.81.6.989

Xenakis, I., Arnellos, A., & Darzentas, J. (2012). The functional role of emotions in aesthetic judgment. *New Ideas in Psychology*, *30*(2), 212–226. https://doi.org/10.1016/j.newideapsych.2011.09.003

Yu, Q., & Nagai, Y. (2020). A new approach to teaching emotional design. *Social Sciences*, *9*(11). https://doi.org/10.3390/socsci9110210

Zentner, M. R. (2001). Preferences for colours and colour: Emotion combinations in early childhood. *Developmental Science*, *4*(4), 389–398. https://doi.org/10.1111/1467-7687.00180

Zettl, H. (2011). *Wadsworth series. Sight, sound, motion: Applied media aesthetics*. Wadsworth Cangage Learning.