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Source: *The American Journal of Psychology*, Vol. 130, No. 3 (Fall 2017), pp. 283-294
Published by: University of Illinois Press
Stable URL: http://www.jstor.org/stable/10.5406/amerjpsyc.130.3.0283
Accessed: 28-08-2017 06:52 UTC

The Science of Art: The Universality of the Law of Contrast

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Visual contrast appears to be an important factor in the appreciation of paintings. However, it has not been determined whether and how the effect of contrast differs between painting characteristics and whether and how it differs between people. We investigated whether the effect of contrast generalizes across cultures, variations in initial contrast levels (i.e., the amount of contrast in the digital reproductions of an original painting) between paintings, painting types (i.e., representational or abstract), and social and cognitive–aesthetic factors (e.g., age, education, art expertise). Our results indicated that people consistently favor high-contrast versions of paintings over their low-contrast counterparts; this effect is stronger for abstract paintings and paintings with a low or moderate initial contrast level; this effect is not influenced by culture, social factors, or cognitive–aesthetic factors; and surprisingly, the aesthetic value of digitized original paintings can be increased by increasing their contrast value. In short, we found empirical support against the universal importance of contrast in relation to painting characteristics but in favor of the universal importance of contrast in relation to people characteristics.

Appendices 1, 2, and 3 are available here: http://www.press.uillinois.edu/journals/ajp/media/science_of_art/

KEYWORDS: contrast, art, paintings, aesthetics, culture

Art and aesthetics have been the focus of investigation across various academic fields. Both psychological (Hekkert & van Wieringen, 1996a, 1996b) and sociological (Silva, 2006) studies provide empirical evidence for cultural, social, and cognitive differences in art appreciation. However, the existence of museums and art history books reveals the possibility of a consensus on artistic value of artworks. On its face, this offers an argument for shared mechanisms or laws of art appreciation. Neuroscientists have hypothesized (Zeki, 2001, 2013) and provided evidence for (Kawabata & Zeki, 2004; Vartanian & Goel, 2004) a universal basis of art appreciation, and previous research has shown several factors to be important in the appreciation of aesthetic stimuli (e.g., contrast; Tinio, Leder, & Strasser, 2011; harmony; Palmer & Griscom, 2012; fractality; Hagerhall, Purcell, & Taylor, 2004; and self-similarity; Amirshahi, Koch, Denzler, & Redies, 2012).

Ramachandran and Hirstein (1999) have proposed a possible framework of mechanisms for such

American Journal of Psychology
Fall 2017, Vol. 130, No. 3 pp. 283–294 • © 2017 by the Board of Trustees of the University of Illinois

a universal basis, describing a set of laws of art appreciation. Although this framework was met with resistance (Hyman, 2010), in combination with sociological and psychological theory it may be an asset for the advancement of scientific understanding of art and aesthetics. The purpose of our study was to test the universality of one of these laws, namely the law of contrast. Experiments were conducted to examine the effect of contrast in paintings on appreciation of the paintings, how this effect differs between painting types, and how it relates to pertinent differentiating factors, deduced from sociological and psychological research.

Psychological research reveals relations between differences in art appreciation and demographic (e.g., age and sex; Furnham & Walker, 2001a, 2001b) and cognitive (e.g., expertise; Hekkert & van Wieringen, 1996a, 1996b; Thomas & Lin, 2002) factors. Although both the symmetry and complexity of works of art are positively related to their appreciation, the effect of complexity is not robust when people are familiarized with the artworks in question (Tinio & Leder, 2009a), and although symmetry cues in stimuli influence preference positively, the use of these cues varies (Jacobsen & Höfel, 2003). Preference for color, shape, and composition varies with individual preference for overall harmony, which is negatively correlated with art expertise (Palmer & Griscom, 2012). In addition, art experts evaluate art differently from laymen. For example, art experts' appreciation appears to be more strongly related to the artworks' originality, whereas the appreciation of laymen is guided predominantly by familiarity (Hekkert & van Wieringen, 1996b). In sum, although every person perceives the same object, attention allocation to, interpretation of, and ultimately appreciation of artworks vary across people (Thomas & Lin, 2002).

Cultural sociology offers another explanation for this differentiation between people's art appreciation. According to sociologist Bourdieu (Bourdieu & Nice, 1980; Bourdieu, 1985), artworks are attributed a symbolic value through social interaction. He argues that an artwork does not have intrinsic artistic value, but that value is attributed through positive evaluation by art authorities (e.g., museums, art critics). Through promotion by galleries, museums, and art critics the status of the artwork, and thereby its artistic value, increases. However, the status of these authorities is also linked to the art they promote. Their status increases or decreases when art is promoted with positive or negative results (e.g., recognition or acquisition by others). In short, artworks' status, appreciation, and consumption are linked to social class. Which artwork is appreciated not only confirms a person or institute's social status, it can also increase their status in relation to others (Bourdieu & Nice, 1980; Bourdieu, 1985).

Empirical research does indeed provide evidence for the associations between art appreciation and factors of socialization. For instance, studies have shown a positive relation between educational level and amount of art consumption (e.g., art museum visits and craft exhibitions; Chan & Goldthorpe, 2007) and between educational level and type of art appreciation (e.g., higher educated prefer more abstract and contemporary art; Silva, 2006). Similarly, Berghman and van Eijck (2009) showed that age and level of education are related to variation in painting style preference. Specifically, appreciation for more contemporary painting styles is linked to the younger and higher educated, whereas the older and lower educated preferred classical painting styles (e.g., Renaissance and landscape paintings). In short, sociological research suggests a link between the status of the artwork and its perceiver, resulting in sociocultural differences in art appreciation.

Although art appreciation appears highly differentiated, the fact of existing consensus in art appreciation remains a quandary. With the advent of neuroaesthetics, researchers have suggested a universal basis of art appreciation and its mechanisms (Ramachandran, 2001; Ramachandran & Hirstein, 1999; Zeki, 2001). If art appreciation is grounded in neurophysiological perception processing, it may offer an explanation for various research results. For instance, naive participants can discern original artworks from compositionally altered versions (Locher, 2003). This suggests that the original's material elements are arranged to elicit a positive affective reaction, and this reaction is disrupted when the composition is altered. Similarly, abstract paintings by professional artists are appreciated over counterparts selected on resemblance, made by children, primates, or elephants (Hawley-Dolan & Winner, 2011). These results are in line with neuroimaging research, which reveals different patterns of brain activity when people view beautiful

rather than ugly paintings (Kawabata & Zeki, 2004; Vartanian & Goel, 2004). In sum, research results point toward a universal neurobiological basis of art appreciation (Cela-Conde, Agnati, Huston, Mora, & Nadal, 2011; Chatterjee, 2011; Nadal, Munar, Capó, Rosselló, & Cela-Conde, 2008; Zeki, 2013).

Ramachandran and Hirstein (1999) contended that because perception is useful for survival, evolution has resulted in perception processing that can have affective rewards. One of the main functions of our visual system is discovering and delineating objects in our visual field (Marr, 1981; Pinker, 1998; Ramachandran, 1990). For this feat distinct cortical areas dedicated to vision rely on extracting correlations between visual elements. To adequately allocate attention, our visual system is attuned to perceive edges of objects (i.e., contrast between the object and its background) and to discard redundant information (i.e., gradient coloring and luminance of the background). In this manner, visual information can be quickly cross-referenced to distinguish objects and events. To promote survival, the process of binding visual elements into unitary events or objects must be reinforcing (Ramachandran & Blakeslee, 1998). In other words, one should be enticed to discover correlates (e.g., being able to distinguish prey, mate, or meal from its background) and be emotionally rewarded for having done so.

From this evolutionary perspective and based on earlier research, Ramachandran and Hirstein (1999) postulated several neurophysiological laws of art appreciation. They argue that because humans to a large extent share one neurophysiological makeup, we are likely to experience similar affective rewarding sensations that result from perception processing. In other words, artwork's distinct material elements and their compositions should trigger a universal reaction in people. The laws they coined include peak shift (exaggeration of shapes), grouping (combining nonadjacent objects to one shape), perceptual problem solving (effort costing constructing of a coherent image), and contrast (distinguishing between adjacent objects). Contrast in particular has been previously studied, and research results indeed show that contrast-rich artworks and other contrast-rich visual stimuli are preferred over their lower-contrast counterparts (Krentz & Earl, 2013; Reber, Winkielman, & Schwarz, 1998; Tinio & Leder, 2009b; Tinio et al., 2011).

Although a neurological explanation of artistic preferences is appealing, current theories are far from exhaustive (Tyler, 1999). Moreover, other factors might be better at accounting for overlap in people's art appreciation. For instance, an artwork's symbolic context appears to play a role in its appreciation. Namely, appreciation for artworks increases or decreases when the artworks are respectively labeled as the product of a professional artist or a hobby painter (Berghman & Van Eijck, 2012). Cognitive differences between experts and nonexperts (e.g., differences in the perception and interpretation of artworks) are suggested as an explanation for the differences in what type of paintings they prefer (e.g., representational vs. abstract; Hekkert & van Wieringen, 1996a) and what they appreciate about them (e.g., subject matter, medium, originality; Hekkert & Van Wieringen, 1996b; Thomas & Lin, 2002). In addition, cognitive differences between people of dissimilar cultures exist, which potentially influences art appreciation. For instance, Americans are better at copying the absolute measures of objects, whereas Japanese people are better at copying their relative measures in relation to their surroundings. This is suggestive of cultural attentional differences guiding perception (Kitayama, Duffy, Kawamura, & Larsen, 2003). And, as stated before, research indicates that there is a relation between people's art preference (i.e., which type of art is appreciated) and their familiarity to paintings, personality, education, and demographic factors (Furnham & Walker, 2001a, 2001b). This is in line with sociologists stressing the role of background characteristics such as culture, age, level of education, and social class as explanation for art appreciation (Berghman & Van Eijck, 2009; McManus & Furnham, 2006; Silva, 2006; Van Eijck, 2011).

In sum, there is evidence for both a neurobiological basis and differentiation due to social and cognitive differences when it comes to art appreciation. It is our expectation that combining neuroaesthetic, psychological, and sociological perspectives will result in a more comprehensive insight into art appreciation and aesthetics. Therefore, we studied suggested universal aesthetic aspects and investigated whether psychological and social participant characteristics influence them. We chose contrast for our experiments, because it is one of the universal aspects that has been demonstrated to be aesthetically pleasing.

However, only unaltered and decreased-contrast copies of paintings have been used in previous research, and neither the initial levels of contrast nor the type of painting (e.g., abstract versus representational) was taken into account (Krentz & Earl, 2013; Tinio et al., 2011; Tinio & Leder, 2009b).

Thus, the purpose of our first experiment was to investigate the effect of increasing and decreasing contrast of paintings of different types and initial contrast levels and whether this effect is related to culture (American vs. Indian) and other participant characteristics that have previously been shown to be of effect in both sociological (e.g., Berghman & Van Eijck, 2009) and psychological (e.g., Hekkert & Van Wieringen, 1996a) research. Because previous research has only compared original images with lower-contrast versions of those images, in our second and third experiment we tested the effects of increased and decreased contrast separately.

EXPERIMENT 1

METHOD AND RESULTS

In this experiment, participants judged which of two paintings they appreciated more. One painting was a high-contrast version of the digital reproduction of an original painting, and the other was a low-contrast version of the same painting. After the experiment, a short questionnaire was administered. Data were analyzed with a repeated-measures analysis of variance. Differences between preference for the high-contrast version and the low-contrast versions of paintings were used as main effect. Variations between painting types and initial levels of contrast were measured as interaction effects. Participant characteristics were added to the analysis as covariates and between-subject factors.

Participants

Participants were 150 American (U.S.) (52% male, mean age = 36.4, *SD* = 12.2) and 150 Indian people (53% male, mean age = 32.1, *SD* = 9.5), recruited via Mechanical Turk. Previous research has shown that experiments performed via Mechanical Turk yield similar outcomes as experiments performed in the lab (Paolacci, Chandler, & Ipeirotis, 2010). Nonetheless, it should be taken into account that we could not control the type of monitor on which our participants viewed the stimuli. Participants were not allowed to perform the experiment on a smartphone.

Both American and Indian participants were included to ensure that we could compare a group of participants culturally congruent to the stimuli (i.e., Western people in regard to paintings from European and American artists) with a group of participants culturally incongruent to the stimuli. Twelve participants (all Indian) were excluded from the analyses because they failed to complete the experiment.

Stimuli

The stimuli were 80 pairs of color reproductions of paintings from digital collections of five established European museums, and we therefore assumed the digital reproduction to be reliable approximations of the actual paintings. We focused on Western art in order to have a somewhat homogeneous sample of stimuli. The period in which the paintings were created ranges from the years 1500 to 2010, and all were painted by either European or American artists, predominantly Dutch or Flemish artists. Half of the 80 original paintings were representational and half were abstract. All stimuli were presented at the same width (500 pixels) and resolution (72 dpi). An overview of all paintings can be found in Appendix 1.

Initial contrast of the paintings was assessed in Adobe Photoshop CS5. Of the selected paintings, 20 were low in initial contrast, 40 were medium in initial contrast, and 20 were high in initial contrast. Luminosity contrast was measured by the lightness and the amount of pixels and the range between the lightest and darkest pixels. The lightness of pixels was measured on a gray scale of 256 shades, ranging from black (0) to white (255). Dark shades of any color translate to values between 0 and 127 and light shades of any color to values between 128 and 255. Thus, the pixels of each painting were translated to gray scores, resulting in a contrast histogram for each painting.

The low contrast level was defined as having a contrast peak (greatest amount of pixels) in the middle six octiles of the contrast histogram and having a range smaller than 190 shades of gray (less than three quartiles). The high contrast level was defined as having a contrast peak in the highest or lowest octile and having a range from 0 to 255 shades of gray. The middle contrast level was defined as the rest of the paintings that had a range larger than 190 shades of gray. No paintings with a contrast peak in the outermost octiles and a range below 190 shades were used (see Appendix 2 for the contrast histograms of the stimuli). To verify our categorization, we measured the standard deviation of gray values

(i.e., root mean square contrast). The higher the standard deviation, the more pixels near black and white compared with the total amount of pixels. On average the painting categories low initial contrast, moderate initial contrast, and high initial contrast had a standard deviation of gray values of 28.58, 40.57, and 44.99, respectively. These three levels of initial contrast were used to control for the possibility of a ceiling effect. Logically, there is a limitation of the amount of contrast that is beautiful. For instance, if contrast is indefinitely increased, all that remains are black and white shapes. By investigating several levels of contrast, we ensured the contrasts were not too high or too low.

In short, the 80 paintings were divided into six categories: representational paintings with low initial contrast (10), representational paintings with medium initial contrast (20), representational paintings with high initial contrast (10), abstract paintings with low initial contrast (10), abstract paintings with medium initial contrast (20), and abstract paintings with high initial contrast (10).

Each pair of artworks consisted of two versions of the same painting: one with low luminosity contrast and one with high luminosity contrast (see Figure 1 for an example). In order to create high-contrast versions of the paintings, dark shades (i.e., shades of gray 0–127) were made darker and light shades (i.e., shades of gray 128–255) were made lighter. Shade of gray 64 (between the first and second quartile) and shade of gray 191 (between the third and fourth quartile) were respectively decreased and increased by 15 shades. The changes were progressively smaller toward the extreme values (0 and 255) and the neutral value (128). At the extreme and neutral values no changes were made. The decrease and increase were reversed for low-contrast versions (see Appendix 3 for a complete list of the original paintings and the manipulations). To verify our manipulation, we measured and compared the average increase (4.07) and decrease (3.61) of the standard deviation of gray values after the manipulation, the sizes of the manipulations did not significantly differ, $t(79) = 1.58$, $p > .05$. Additionally, we tested whether our manipulations affected the paintings' global luminance by comparing the average gray value of the unmanipulated paintings (80.83) with the high-contrast copies (79.34), $t(79) = 0.85$, $p > .05$, and low-contrast copies (80.59), $t(79) = 0.44$, $p > .05$. Global luminance in the manipulated paintings did not significantly differ from that of the unmanipulated paintings.

Procedure

In each trial, the participants viewed a pair of paintings (one on the left side and one on the right side of the monitor) and judged which of the two paintings they liked better and whether they were familiar with the painting. Half of the trials the high-contrast version were presented on the left and half of the trials the high-contrast version were presented on the right. The pairs of paintings were presented in random order. For analysis of the results, preference proportions per subject per painting category were calculated for (a) high-contrast paintings in relation to the total number of paintings in the category and (b) the low-contrast paintings in relation to the total amount of paintings in the category. For instance, a person would have a proportion score of 0.75 for (a) and 0.25 for (b) if this person preferred 15 high-contrast copies 5 of the low-contrast copies of repre-

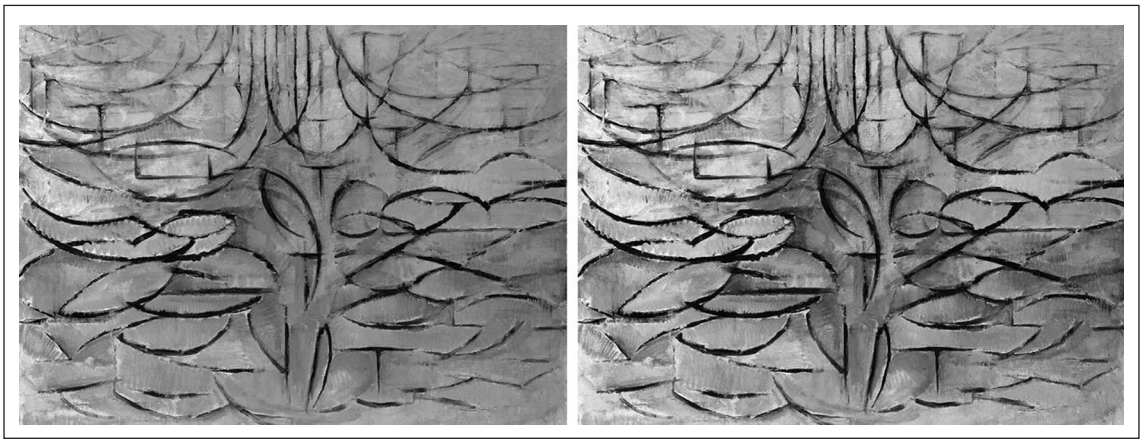

FIGURE 1. Stimulus example. The painting copy on the left is decreased in luminosity contrast; the contrast of the one on the right is increased

sentational paintings with a medium initial contrast level of the 20 representational paintings with a medium initial contrast level.

After the experiment, participants filled in the questionnaire. They were divided into two groups by education. Separate groups were created for American and Indian participants because of central tendency differences in education between the groups. The American low-education group consisted of educational levels of up to a 2-year college degree. The American high-education group consisted of educational levels of a 4-year college degree and higher. The Indian low-education group consisted of educational levels up to a 4-year college degree. The Indian high-education group consisted of educational levels of a master's degree and higher.

Participants were divided into two groups by annual household income. Separate groups were created for American and Indian participants because of the large differences in income between the groups. The American low-income group consisted of incomes up to $39,999 per year, and the American high-income group consisted of incomes of $40,000 and higher per year. The Indian low-income group consisted of incomes up to $19,999 per year, and the Indian high-income group consisted of incomes of $20,000 and higher.

Knowledge of art and interest in art were assessed on a visual analog scale ranging from 1 to 100 with a self-report question.

Because participants recognized very few paintings (50% of participants recognized three or fewer paintings), familiarity was not taken into account in analyses.

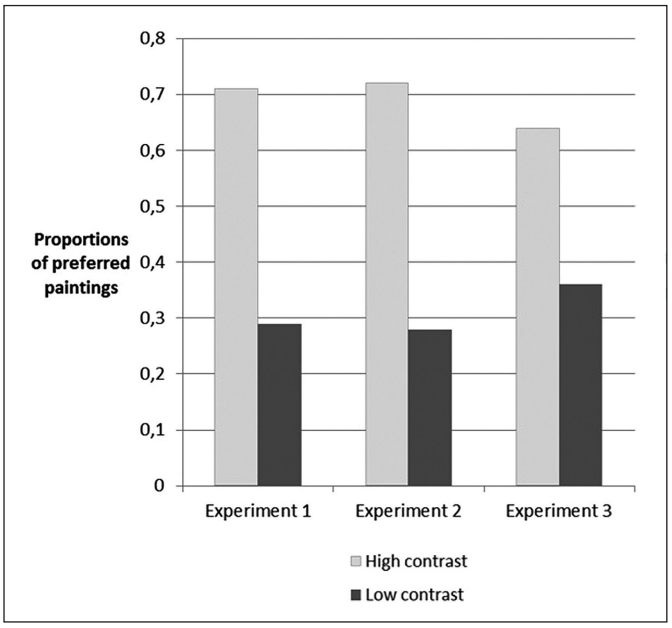

FIGURE 2. Proportions of preferred paintings per experiment. For Experiment 1 the light gray bar represents high-contrast versions of paintings and the dark gray bar low-contrast versions of paintings. For Experiment 2 the light gray bar represents original paintings and the dark gray bar low-contrast versions of paintings. For Experiment 3 the light gray bar represents high-contrast versions of paintings and the dark gray bar original paintings

RESULTS

A 2 (manipulated contrast: high vs. low) × 2 (type: representational vs. abstract) × 3 (initial contrast: low vs. medium vs. high) repeated-measures ANOVA revealed a significant main effect of manipulated contrast, $F(1, 287) = 363.86$, $p < .0001$, $\eta_p^2 = .56$ (Figure 2), a significant manipulated contrast × type interaction, $F(1, 287) = 57.16$, $p < .0001$, $\eta_p^2 = .17$, a significant manipulated contrast × initial contrast interaction, $F(2, 186) = 67.21$, $p < .0001$, $\eta_p^2 = .32$, and a significant manipulated contrast × type × initial contrast three-way interaction, $F(2, 286) = 18.14$, $p < .0001$, $\eta_p^2 = .11$.

Three post hoc t tests for the three types of initial contrast and six post hoc t tests for the three types of initial contrast separately for the two types of paintings revealed that all mean proportions of high-contrast scores differed significantly from each other (all ps < .05, Bonferroni corrected), except for the mean proportions of the abstract paintings with low initial contrast and the abstract paintings with medium initial contrast ($p > .05$, Bonferroni corrected). See Table 1 for an overview of the proportions per condition.

When the cultural (culture: Indian vs. American), social (age: high vs. low; education: high vs. low; and income: high vs. low), and cognitive–aesthetic variables (knowledge of art and interest in art) were entered in a stepwise regression model predicting the effect of contrast, none were significant (all ps > .05).

REPRODUCTION OF EXPERIMENT 1 UNDER CONTROLLED CONDITIONS

This experiment has the same design as Experiment 1, except the experiment was performed in the laboratory under controlled circumstances. Stimuli were presented on 22″ TFT widescreen displays (resolution 1,920 × 1,200, ratio 16:10) with color depth 32 bit

TABLE 1. Mean (*SD*) Proportions of Preference for Higher-Contrast Versions of Paintings by Experiment and Condition

Experiment 1 (low- vs. high-contrast versions)	Type of painting	Initial contrast	Mean (*SD*) proportion of preference for higher-contrast versions
	Representational	Low	.74 (.23)
		Medium	.68 (.25)
		High	.61 (.29)
	Abstract	Low	.77 (.16)
		Medium	.78 (.21)
		High	.69 (.23)
	Total	Total	.72 (.19)
Replication of Experiment 1 in laboratory	**Type of painting**	**Initial contrast**	**Mean (*SD*) proportion of preference for higher-contrast versions**
	Representational	Low	.70 (.19)
		Medium	.60 (.17)
		High	.43 (.21)
	Abstract	Low	.78 (.11)
		Medium	.80 (.10)
		High	.60 (.22)
	Total	Total	.65 (.11)
Experiment 2 (original vs. low-contrast version)	**Type of painting**	**Initial contrast**	**Mean (*SD*) proportion of preference for higher-contrast versions**
	Representational	Low	.75 (.19)
		Medium	.70 (.18)
		High	.70 (.20)
	Abstract	Low	.73 (.17)
		Medium	.74 (.15)
		High	.69 (.19)
	Total	Total	.72 (.14)
Experiment 3 (original vs. high-contrast version)	**Type of painting**	**Initial contrast**	**Mean (*SD*) proportion of preference for higher-contrast versions**
	Representational	Low	.64 (.20)
		Medium	.65 (.16)
		High	.62 (.21
	Abstract	Low	.65 (.16)
		Medium	.67 (.17)
		High	.59 (.15)
	Total	Total	.64 (.12)

and a refresh rate of 59 Hz. The distance between the display and the participants was approximately 60 cm.

Participants

Participants were 24 psychology students (46% male, mean age 26.7, $SD = 3.4$) recruited from the Erasmus University Rotterdam. They received credits for their participation.

Stimuli

The stimuli in this experiment were identical to those of Experiment 1.

Procedure

The procedure of this experiment was identical to that of Experiment 1, except that annual household income, education, and knowledge of and interest in art were not recorded.

RESULTS

A 2 (manipulated contrast: high vs. low) × 2 (type: representational vs. abstract) × 3 (initial contrast: low vs. medium vs. high) repeated-measures ANOVA revealed a significant main effect of manipulated contrast, $F(1, 23) = 44.89$, $p < .0001$, $\eta_p^2 = .66$ (Figure 2), a significant manipulated contrast × type interaction, $F(1, 23) = 28.23$, $p < .0001$, $\eta_p^2 = .55$, a significant manipulated contrast × initial contrast interaction, $F(2, 22) = 32.13$, $p < .0001$, $\eta_p^2 = .58$, and a significant manipulated contrast × type × initial contrast three-way interaction, $F(2, 22) = 4.04$, $p < .05$, $\eta_p^2 = .15$.

Three post hoc t tests for the three types of initial contrast and six post hoc t tests for the three types of initial contrast separately for the two types of paintings revealed that all mean proportions of high-contrast scores differed significantly from each other (all ps < .05, Bonferroni corrected), except for the mean proportions of the abstract paintings with low initial contrast and the abstract paintings with medium initial contrast ($p > .05$, Bonferroni corrected). The overall preference for high-contrast paintings was slightly lower in this experiment (.65) than in Experiment 1 (.72). See Table 1 for an overview of the proportions per condition.

EXPERIMENT 2

This experiment has the same design as Experiment 1, except participants judged between original-contrast and low-contrast versions of the paintings.

METHOD

Participants

Participants were 75 American people (28.8% male, mean age = 38.1, $SD = 13.9$), recruited via Mechanical Turk. Two participants were excluded from analysis because they failed to complete the experiment.

Stimuli

The stimuli in Experiment 2 were identical to those in Experiment 1, except instead of comparing high- and low-contrast versions of the same painting, participants judged between original contrast and low-contrast versions. Because the same low-contrast versions of the paintings as in Experiment 1 were used, the difference in contrast between the pairs in Experiment 2 was half as large as in Experiment 1.

Procedure

The procedure of Experiment 2 was identical to that of Experiment 1, except the question of familiarity was not asked because of the very low familiarity of the paintings to participants of the first experiment. In addition, 40 filler items were included to divert the attention of participants away from the differences in contrast. Each filler consisted of two versions of an abstract or representational painting, the original and a mirrored copy (no differences in contrast were applied). Additionally, at the end of the experiment participants were asked what they thought the experiment was about. Two participants specifically mentioned the liking of higher contrast, and eight participants mentioned contrast between other features (e.g., presentation to the left or right, orientation of the pictures). Excluding these participants does not significantly change the results.

RESULTS

For Experiment 2, a 2 (manipulated contrast: original vs. low) × 2 (type: representational vs. abstract) × 3 (initial contrast: low vs. medium vs. high) repeated-measures ANOVA revealed a significant main effect of manipulated contrast, $F(1, 72) = 176.28$, $p < .0001$, $\eta_p^2 = .71$ (Figure 2), a significant manipulated contrast × initial contrast interaction, $F(2, 71) = 3.54$, $p < .05$, $\eta_p^2 = .09$, and a significant manipulated contrast × type × initial contrast three-way interaction, $F(2, 71) = 3.13$, $p = .05$, $\eta_p^2 = .08$. Note that, unlike in Experiment 1, the manipulated contrast × type interaction was not significant, $p > .9$.

Three post hoc *t* tests for the three types of initial contrast revealed that only the mean proportions of normal contrast scores for high initial contrast versus low initial contrast differ significantly from each other ($p < .05$, Bonferroni corrected, other ps $> .05$, Bonferroni corrected). See Table 1 for an overview of the proportions per condition.

When the social and cognitive–aesthetic variables were entered in a stepwise regression model predicting the effect of contrast, none were significant (all ps $> .05$).

EXPERIMENT 3

This experiment has the same design as Experiments 1 and 2, except participants judged between original-contrast and high-contrast versions of the paintings. Two participants specifically mentioned the liking of higher contrast, and seven participants mentioned contrast between other features. Again, excluding these participants does not significantly change the results.

METHOD

Participants

Participants were 75 American people (38.7% male, mean age = 38.3, $SD = 12.6$), recruited via Mechanical Turk. All participants completed the experiment.

Stimuli

The stimuli in Experiment 3 were identical to those in Experiment 2, except instead of comparing low-contrast and original-contrast versions of the same painting, participants judged between high-contrast and original-contrast versions.

Procedure

The procedure of Experiment 3 was identical to that of Experiment 2.

RESULTS

For Experiment 3, a 2 (manipulated contrast: high vs. original) × 2 (type: representational vs. abstract) × 3 (initial contrast: low vs. medium vs. high) repeated-measures ANOVA revealed a significant main effect of manipulated contrast, $F(1, 74) = 91.72$, $p < .0001$, $\eta_p^2 = .55$ (Figure 2) and a significant manipulated contrast × initial contrast interaction, $F(2, 73) = 6.29$, $p < .005$, $\eta_p^2 = .15$. Again, the manipulated contrast × type interaction was not significant, $p > .8$, nor was the manipulated contrast × type × initial contrast three-way interaction significant, $p > .1$.

Three post hoc *t* tests for the three types of initial contrast revealed that only the mean proportions of high-contrast scores for high initial contrast versus medium initial contrast differ significantly from each other ($p < .05$, Bonferroni corrected, other ps $> .05$, Bonferroni corrected). See Table 1 for an overview of the proportions per condition.

When the social and cognitive–aesthetic variables were entered in a stepwise regression model predicting the effect of contrast, none were significant (all ps $> .05$).

DISCUSSION

Our results indicate that people consistently favor high-contrast versions of digitized paintings over their low-contrast counterparts and that this effect partially depends on painting characteristics. On the other hand, participant characteristics seem to be of minor importance because this preference for higher contrast is not influenced by social and cognitive–aesthetic factors. Most notably, neither age, nationality, income, nor education was predictive of the main effect of contrast.

In Experiment 1 we found the effect of contrast to be larger for abstract paintings than for representational paintings, which may be explained by Ramachandran and Hirstein's (1999) theory that the aesthetic value of a discrete artwork depends on several laws of art. We suggest that the law of contrast is of greater relative importance in abstract paintings than in representational paintings, because in abstract paintings there is less emphasis on the realistic interpretation of the painting, and thus fewer laws seem to readily apply. Additionally, contrast may be of more absolute importance in abstract paintings, because they consist of adjacent shapes that differ in color and luminosity contrast and lack representation.

Alternatively, the difference may be a result of a layer of varnish or dirt covering the older representational paintings, lowering their initial level of contrast. Because this problem is less prevalent in abstract paintings, the effect of type we find may be confounded by the varnish or dirt on representational paintings. However, as discussed later, we found the

effect of contrast to be smaller for paintings with high initial contrast, which is at odds with the effect being larger for abstract paintings. We therefore expect these effects to be caused by differences between representational and abstract art other than initial contrast. These findings were not replicated in the other experiments, which may be explained by the smaller contrast differences between the high-contrast and low-contrast stimuli in Experiments 2 and 3.

In addition, in all experiments there was a significant interaction between manipulated contrast and initial contrast. The effects for paintings initially high in contrast were smaller, suggestive of a ceiling effect for these stimuli. In Experiment 1 the effect of initial contrast was smaller in abstract paintings, again suggestive of a ceiling effect, because the main effect of contrast was already larger in abstract paintings.

Experiments 2 and 3 empirically support the claim of the existence and relevance of the law of contrast because they compare original paintings with manipulations of the paintings with both increased and decreased contrast. Previous studies have shown that decreasing contrast lowers appreciation. We show that it is also possible to increase the aesthetic value of artworks by increasing the amount of contrast, indicating that original art can be made more aesthetically appealing by simple manipulation. If other factors were greatly changing with the alteration in contrast, it may have been expected that changing the contrast in any direction would worsen the composition of the entire painting. Because the effect works both ways (decreasing contrast decreases appreciation and increasing contrast increases appreciation), it seems contrast is indeed the relevant factor.

Our study has several limitations. First, as Hekkert and van Wieringen (1996a) previously pointed out, it cannot be expected that manipulating one element of a work of art really changes only that dimension and has no impact on other elements, nor that the entire aesthetic experience can be fully captured.

Second, the paintings are presented on a monitor rather than in their original form; for example, the texture of the paintings is left out of the picture, limiting the ecological validity. However, previous research has shown that participants respond similarly to original paintings and (digital) reproductions (Locher, Smith, & Smith, 1999). Also, because participants performed the task on their personal computer, the monitors that have been used will not have been identical, and thus the viewing conditions (e.g., gamma settings of the monitor) varied between participants beyond experimental control. Therefore, the absolute size of the manipulation may differ slightly between participants, but we show that the direction of the manipulation is the same for all participants. Moreover, in the replication of Experiment 1 under controlled conditions we show that the main effect of contrast is similar to that of the original experiment, suggesting that the results are not meaningfully influenced by the different viewing conditions under which participants performed the experiment via Mechanical Turk. It should be noted that the interaction effects between contrast and painting type and between contrast and initial level of contrast have larger effect sizes in the replication. This seems to be caused by a decrease in appreciation of representational paintings high in initial contrast, suggesting that in this condition the expected ceiling effect of contrast is reached sooner on the calibrated monitors that were used in the laboratory.

Third, because we use digital reproductions, the initial levels of contrast are estimates. We deemed this an acceptable limitation, because our study pertains to the effect of luminosity contrast in general, and we categorized our stimuli by initial level of contrast to investigate the possibility of a ceiling effect. Also, as mentioned, we assumed the digital reproductions to be reliable approximations of the actual paintings, because all were retrieved from the digitized collection of renowned museums.

Fourth, knowledge of and interest in art were measured only by self-report, and thus the reliability of these measures is unknown.

Fifth, participants' familiarity with the paintings was too low to take into account, so our results cannot be generalized to both familiar and unfamiliar paintings. Indeed, previous research has shown that the effect of painting characteristics on appreciation is less robust for familiar works of art (Tinio & Leder, 2009a).

Nonetheless, given the robustness of our results and effect sizes, we conclude that it is probable that contrast is of universal importance in the aesthetic value of paintings and that people characteristics are of minor influence. Painting characteristics, on the

other hand, do seem to partially determine how important contrast is in the appreciation of a painting.

We suggest further research to focus on replicating these experiments in samples from other cultures and extending the amount of investigated background characteristics of the participants. For instance, it would be informative to find out whether the effect remains as robust when considered in combination with contextual factors (e.g., labeling the copies of paintings as either "original" or "forgery"; Berghman & Van Eijck, 2012) or when non-Western paintings are used as stimuli. Moreover, research should be directed at testing the other laws proposed by Ramachandran and Hirstein (1999), given that the framework they provided is both viable and testable. For instance, the law of peak shift can be tested, which poses that exaggerated versions of people or objects are more appealing than generic versions (e.g., the extreme musculature of Greek statues serves as a so-called supernormal stimulus for the human male). This could experimentally be achieved by manipulating human bodies in paintings toward the extreme.

With this article we hope to inspire more interdisciplinary research into art and art appreciation, contributing to a more complete understanding of art and its mechanisms.

NOTES

N. N. N. van Dongen and J. Zijlmans contributed equally to the development of the study, the data analysis, and the writing of the article. N. N. N van Dongen created the stimuli. J. Zijlmans programmed the experiments.

We thank Katinka Dijkstra and Koen van Eijck for their advice and support and the Institute of Psychology of the Erasmus University Rotterdam for providing the funds necessary to complete this project.

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REFERENCES

Amirshahi, S. A., Koch, M., Denzler, J., & Redies, C. (2012). PHOG analysis of self-similarity in aesthetic images. *Proceedings of SPIE (Human Vision and Electronic Imaging XVII), 8291,* 82911J. doi:10.1117/12.911973

Berghman, M., & Van Eijck, K. (2009). Visual arts appreciation patterns: Crossing horizontal and vertical boundaries within the cultural hierarchy. *Poetics, 37*(4), 34865. doi:10.1016/j.poetic.2009.06.003

Berghman, M., & Van Eijck, K. (2012). Beeldende kunst in een symbolische context [Visual art in a symbolic context]. In I. Gloriex, J. Siongers, & W. Smits (Eds.), *Cultuursociologie buiten de lijnen* (pp. 394–367). Leuven, Belgium: Lannoo Campus.

Bourdieu, P. (1985). The market of symbolic goods. *Poetics, 14,* 13–44.

Bourdieu, P., & Nice, R. (1980). The production of belief: Contribution to an economy of symbolic goods. *Media, Culture & Society, 2*(3), 261–293. doi:10.1177/016344378000200305

Cela-Conde, C. J., Agnati, L., Huston, J. P., Mora, F., & Nadal, M. (2011). The neural foundations of aesthetic appreciation. *Progress in Neurobiology, 94*(1), 39–48. doi:10.1016/j.pneurobio.2011.03.003

Chan, T. W., & Goldthorpe, J. H. (2007). Social stratification and cultural consumption: The visual arts in England. *Poetics, 35*(2–3), 168–190. doi:10.1016/j.poetic.2007.05.002

Chatterjee, A. (2011). Neuroaesthetics: A coming of age story. *Journal of Cognitive Neuroscience, 23,* 53–62. doi:10.1162/jocn.2010.21457

Furnham, A., & Walker, J. (2001a). The influence of personality traits, previous experience of art, and demographic variables on artistic preference. *Personality and Individual Differences, 31,* 997–1017.

Furnham, A., & Walker, J. (2001b). Personality and judgements of abstract, pop art, and representational paintings. *European Journal of Personality, 15,* 57–72.

Hagerhall, C. M., Purcell, T., & Taylor, R. (2004). Fractal dimension of landscape silhouette outlines as a predictor of landscape preference. *Journal of Environmental Psychology, 24*(2), 247–255. doi:10.1016/j.jenvp.2003.12.004

Hawley-Dolan, A., & Winner, E. (2011). Seeing the mind behind the art: People can distinguish abstract expressionist paintings from highly similar paintings by children, chimps, monkeys, and elephants. *Psychological Science, 22,* 435–441. doi:10.1177/0956797611400915

Hekkert, P., & van Wieringen, P. C. W. (1996a). Beauty in the eye of expert and nonexpert beholders: A study in the appraisal of art. *American Journal of Psychology, 109,* 389–407.

Hekkert, P., & van Wieringen, P. C. W. (1996b). The impact of level of expertise on the evaluation of original and altered versions of post-impressionistic paintings. *Acta Psychologica, 94,* 117–131. doi:10.1016/0001-6918(95)00055-0

Hyman, J. (2010). Art and neuroscience. *Boston Studies in the Philosophy of Science, 262,* 245–261. doi:10.1007/978-90-481-3851-7

Jacobsen, T., & Höfel, L. (2003). Descriptive and evaluative judgment processes: Behavioral and electrophysiological indices of processing symmetry and aesthetics. *Cognitive, Affective, & Behavioral Neuroscience, 3,* 289–99. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15040549

Kawabata, H., & Zeki, S. (2004). Neural correlates of beauty. *Journal of Neurophysiology, 91,* 1699–1705. doi:10.1152/jn.00696.2003

Kitayama, S., Duffy, S., Kawamura, T., & Larsen, J. T. (2003). Perceiving an object and its context in different cultures: A cultural look at new look. *Psychological Science, 14,* 201–206. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12741741

Krentz, U., & Earl, R. K. (2013). The baby as beholder: Adults and infants have common preferences for original art. *Journal of Aesthetics, Creativity, and the Arts, 7*(2), 181–190. doi:10.1037/a0030691

Locher, P. J. (2003). An empirical investigation of the visual rightness theory of picture perception. *Acta Psychologica, 114,* 147–164. doi:10.1016/j.actpsy.2003.07.001

Locher, P., Smith, L., & Smith, J. (1999). Original paintings versus slide and computer reproductions: A comparison of viewer responses. *Empirical Studies of the Arts, 17*(2), 121–129. doi:10.2190/R1WN-TAF2-376D-EFUH

Marr, D. (1981). *Vision*. San Francisco, CA: Freeman and Sons.

McManus, I. C., & Furnham, A. (2006). Aesthetic activities and aesthetic attitudes: Influences of education, background and personality on interest and involvement in the arts. *British Journal of Psychology, 97*(Pt 4), 555–587. doi:10.1348/000712606X101088

Nadal, M., Munar, E., Capó, M. À., Rosselló, J., & Cela-Conde, C. J. (2008). Towards a framework for the study of the neural correlates of aesthetic preference. *Spatial Vision, 21*(3), 379–396. doi:10.1163/156856808784532653

Palmer, S. E., & Griscom, W. S. (2012). Accounting for taste: Individual differences in preference for harmony. *Psychonomic Bulletin & Review, 20,* 453–461. doi:10.3758/s13423-012-0355-2

Paolacci, G., Chandler, J., & Ipeirotis, P. G. (2010). Running experiments on Amazon Mechanical Turk. *Judgment and Decision Making, 5*(5), 411–419.

Pinker, S. (1998). *How the mind works*. New York, NY: William Morrow.

Ramachandran, V. S. (1990). Visual perception in people and machines. In A. Blake & T. Troscianko (Eds.), *AI and the eye* (pp. 21–77). Chichester, England: Wiley.

Ramachandran, V. S. (2001). Sharpening up "the science of art." *Journal of Consciousness Studies, 8*(1), 9–29.

Ramachandran, V. S., & Blakeslee, S. (1998). *Phantoms in the brain*. New York, NY: William Morrow.

Ramachandran, V. S., & Hirstein, W. (1999). The science of art. *Journal of Consciousness Studies, 6*(6–7), 15–51.

Reber, R., Winkielman, P., & Schwarz, N. (1998). Effects of perceptual fluency on affective judgements. *Psychological Science, 9,* 45–48.

Silva, E. (2006). Distinction through visual art. *Cultural Trends, 15*(2), 141–158. doi:10.1080/09548960600712942

Thomas, G. V., & Lin, S. F. (2002). Development of understanding of popular graphic art: A study of everyday aesthetics in children, adolescents, and young adults. *International Journal of Behavioral Development, 26*(3), 278–287. doi:10.1080/01650250143000157

Tinio, P. P. L., & Leder, H. (2009a). Just how stable are stable aesthetic features? Symmetry, complexity, and the jaws of massive familiarization. *Acta Psychologica, 130,* 241–250. doi:10.1016/j.actpsy.2009.01.001

Tinio, P. P. L., & Leder, H. (2009b). Natural scenes are indeed preferred, but image quality might have the last word. *Psychology of Aesthetics, Creativity, and the Arts, 3*(1), 52–56. doi:10.1037/a0014835

Tinio, P. P. L., Leder, H., & Strasser, M. (2011). Image quality and the aesthetic judgment of photographs: Contrast, sharpness, and grain teased apart and put together. *Psychology of Aesthetics, Creativity, and the Arts, 5*(2), 165–176. doi:10.1037/a0019542

Tyler, C. W. (1999). Is art lawful? *Science, 285*(5428), 673–674.

Van Eijck, K. (2011). The impact of religious identity and social orientations on visual arts appreciation. *European Sociological Review, 28*(3), 394–407. doi:10.1093/esr/jcr006

Vartanian, O., & Goel, V. (2004). Neuroanatomical correlates of aesthetic preference for paintings. *Cognitive Neuroscience and Neuropsychology, 15*(5), 893–897. doi:10.1097/01.wnr.00001

Zeki, S. (2001). Artistic creativity and the brain. *Science, 293*(5527), 51–52.

Zeki, S. (2013). Clive Bell's "Significant Form" and the neurobiology of aesthetics. *Frontiers in Human Neuroscience, 7*(730), 2–33. doi:10.3389/fnhum.2013.00730