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Significances and Aesthetic Values of Straight Lines

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Abstract

The straight line is an important element of visual language. This type of line is generally less studied, and the dedicated literature contains mainly theoretical assertions. The present paper presents the results of a complex experiment that had as general objective the investigation of straight line in terms of significance and aesthetic value. Following the application of different statistical methods, the following conclusions were reached: a) a general significance cannot be associated with every straight line, and in the few cases when an associated significance was outlined, the correlation was of medium intensity; b) people prefer associations with concrete elements to the detriment of abstract elements; c) the characteristics of the line that condition the aesthetic evaluation are: the length, the inclination, the position within the observed space and the number of space edges reached; d) the straight line with a high aesthetic content is long, centrally placed, touches two edges and is not inclined (with one notable exception); e) the associated significance (word or phrase) is the one that imposes the positive or negative appreciation of the straight line.

Rezumat

Linia dreaptă este un element important al limbajului vizual. Acest tip de linie este în general puţin studiat, iar literatura de specialitate conţine mai ales aserţiuni teoretice. Lucrarea de faţă cuprinde rezultatele unui experiment complex care a avut ca obiectiv general investigarea liniei drepte din punct de vedere al semnificaţiei şi al valorii estetice. În urma aplicării a diferite metode statistice, s-a ajuns la următoarele concluzii: a) nu se poate asocia o semnificaţie general valabilă fiecărei linii drepte, iar în puţinele cazuri când s-a conturat o semnificaţie asociată, corelaţia a fost de intensitate medie; b) oamenii preferă asocieri cu elemente concrete în defavoarea elementelor abstracte; c) caracteristicile liniei care condiţionează evaluarea estetică sunt: lungimea, înclinarea, poziţia în cadrul spaţiului observat şi numărul de margini ale spaţiului atinse; d) linia dreaptă cu un conţinut estetic ridicat este lungă, plasată central, atinge două margini şi nu este înclinată (cu o excepţie notabilă); e) semnificaţia asociată (cuvânt sau expresie) este cea care impune aprecierea pozitivă sau negativă a liniei drepte.

Keywords: straight line, visual language, aesthetic value

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1. Introduction

Architects and designers use visual language to give expressiveness to their creations, but especially to convey messages about values, attitudes, context, etc. A less studied element of visual language is the line. There is no doubt that the line contributes to the aesthetic and semantic value of a building or product either as an independent element or as a resultant edge at the intersection of two surfaces. Textile design expert Marian Davis considered that the line had a relatively long range of characteristics [1]: track; thickness; continuity; edge clarity; contour; consistency; length; direction.
From the point of view of the track, the lines are straight, curved, etc. Justified or not, more attention was paid to curved lines. Given that in nature straight lines are rare, and curved ones are much more common, the hypothesis was launched (later verified by scientific experiments) that humans prefer curved objects [2, 3, 4]. But curved lines are not the subject of this paper.

The well-known modernist painter and theorist Wassily Kandinsky was the one who analysed the straight line in-depth, but unfortunately his approach was predominantly empirical [5]. Kandinsky considered the horizontal straight line to be the simplest straight line. The horizontal straight line was unconsciously associated by humans with the space in which they existed. The horizontal straight line was considered a cold element. The vertical straight line was a warm element. The diagonal straight line (at 45°) was a cold-hot game. All other straight lines, called free lines, were deviations from the diagonal.

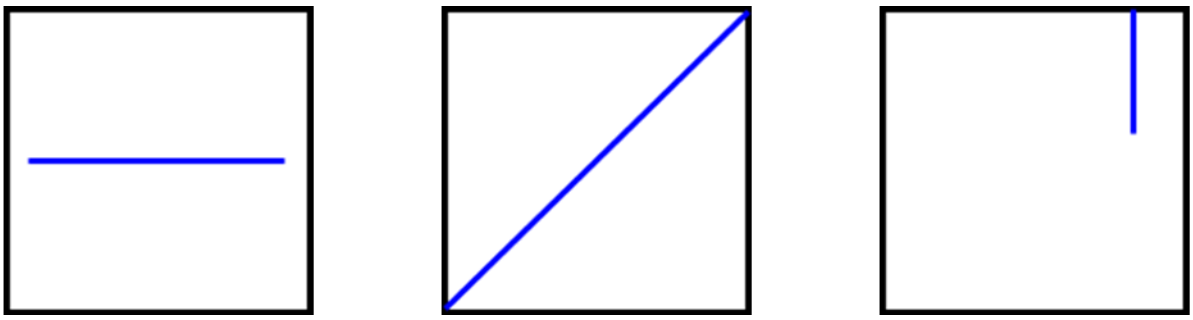
The interior designer John Pile wrote that horizontal lines were associated with peace, calm and rest. Gravity attracted bodies until they met a support element and they arranged themselves in a horizontal line. Humans associated horizontally with rest and sleep. The floor and the ceiling - horizontal par excellence - were surfaces that gave the space a character of soothing normality. "[Vertical lines] suggested stability and immobility and, by extension, dignity and permanence." Vertical lines can be seen as elementary structures of resistance [6].

Beyond the assumptions presented above, there were also experimental approaches to identify the significances of different types of straight lines. Andrei Dumitrescu [7] organised an experiment in which the participants were invited to draw straight lines of paper squares, having all the freedom of expression. Afterwards, participants were asked to associate each line with a word or phrase. The results of the experiment were interpreted in terms of line-significance correlations and, respectively, the way straight lines were drawn. People tended to draw vertical lines from one edge of the drawing space to the other. They avoided drawing lines that touched only one edge. People tend to place straight lines in the centre of the drawing space. Also, people tended to draw mostly vertical and horizontal lines to the detriment of inclined ones. When asked to associate the line with a significance, subjects indicated neutral significances, avoiding positive or negative significances. Subjects preferred concrete significances and avoided abstract significances. An important conclusion of the experiment was that people first consider the angle of inclination of the straight line when seeking to discover its significance. The other parameters mattered relatively little. The results of the experiment did not confirm that the lines have thermal connotations, as Wassily Kandinsky suggested, nor that the diagonal lines had a more dynamic nature than the others.
A similar theoretical modernist approach was in the case of polygons (composed, as was well known, of straight lines). Kandinsky and other modernist thinkers have hypothesized that each polygon was best suited to a single colour (the triangle would be yellow, the square - red…). A series of experimental researches [8-12] have revealed that the correlation between polygons and colours was medium at best and, moreover, only one association indicated by Kandinsky has been confirmed experimentally: the triangle being yellow.

2. Design of experiment

Based on the findings of the literature, as well as on previous research, the following research objectives (RO) were proposed, expressed in the form of questions:
RO1. Can a significance (expressed in a word or phrase) be associated with a straight line? If so, is the correlation strong?
RO2. Can people associate a given straight line with an abstract significance as easily as they do with a concrete significance?
RO3. What are the values of the line's characteristics that give it a high aesthetic content?
RO4. Do the line characteristics directly condition the aesthetic assessment of the straight line?
Ro5. Do the characteristics of the straight line interact with each other?
RO6. Are people able to evaluate by positive / negative attributes the association between a line and a certain significance?

To find the answers to the above questions, a three-phase experiment was designed. In the first phase, 18 figures were generated differentiated by the characteristics of the line inside. Each figure was composed of a blue line placed in a white square with black edges. The characteristics considered were: length (values: short; long), inclination (values: horizontal; vertical; inclined at 45 degrees), position within the square (values: central; lateral) and the number of edges reached (values: 0; 1; 2). In Figure 1, three of the 18 figures are shown as an example. Experiment participants were asked to freely associate each line with a significance (expressed by a word or phrase). The final aim of the first phase was to identify for each line the 6 most used significances.



a. long, horizontal, central, 0 edge reached | b. long, inclined, central, 2 edges reached | c. short, vertical, lateral, 1 edge reached

Figure 1. Sample of figures used in experiment

In the second phase, an electronic questionnaire was made and it contained the 18 figures used in the first phase. Each figure was accompanied by the requirement: "Choose from the list the corresponding significance of the line in figure…". The choice was made using a pop-down menu that contained the 6 words or phrases most used in the first phase. The final aim of the second phase was to identify the most used significance for each line, given that the options were limited.

In the third phase, only the significances of the lines on the first position in the second phase were preserved. A new electronic questionnaire was designed with two questions for each line (represented by the same figure as in the previous phases):
1. Evaluate the aesthetic value of the line in Figure…, taking into account its length, inclination, position in the square and number of edges reached. (The evaluation was performed using a 7-point Likert scale: 1 - very ugly; 7 - very beautiful.)
2. Considering the aesthetics of the whole line-square ensemble, (…"*significance*"…) does the line seem positive or negative?
The direct connotations of the significances were 8 positive, 8 negative and 2 neutral. The purpose of this phase was to answer the questions asked by the research objectives.

3. Experimental results

3.1. Phase 1

In the first phase, there were 356 participants (201 female and 155 male). All participants were students at a large technical university in Romania. Participants were not financially rewarded for their work. The previously generated figures were presented to the participants on computer screens. The same computer screen model was used in all sessions. Participants were asked to carefully observe the lines and pay special attention to the characteristics. Based on the observed characteristics, participants freely associated each line with a significance, expressed by a word or phrase that was recorded. Then, the author centralized the obtained data.

From the point of view of the significance type, 69.55% of the words had a concrete significance (Min = 56.74%; Max = 80.62%), and 30.45% - an abstract significance. The most frequently repeated words were identified and selected. The remaining words were analysed in search for synonyms or words with a significance very close to that of the words or phrases already identified. These words have been replaced with their synonyms in order to obtain a statistic of the most commonly used significances. The most frequently used words and phrases were the following: “Folded sheet” (for a complete diagonal) - 15.2%; “Lake / sea / ocean” (for a long horizontal line placed at the bottom) - 12.6%; “Straight line for text alignment” (for a long vertical line placed on the left) - 12.6%. The remaining significances were not repeated more than 10%.

A 6-position top was established for each line. As abstract significances did not appear in the top of all straight lines, it was decided that each list should contain at least one abstract significance. If no abstract significance appeared in a list, then the best-placed abstract significance was automatically moved to the last (sixth) position. After completing the lists, the second phase started.

3.2. Phase 2

The participation at this phase of the experiment was 389 people (239 women and 150 men). No participants from this phase were involved in the first phase. All participants were students at a large technical university in Romania. Participants were not financially rewarded for their work. Participants were asked to carefully observe the lines before making the choice and to pay attention to the characteristics of each line (length, inclination, position within the square and the number of edges touched). As the questionnaire was electronic, measures were taken to use the same computer screen model in all sessions.

After performing the statistics, it was found that in 14 cases out of 18, the line’s significance placed on the first position changed. There was a general (predictable) increase in the percentages of the significances of the lines. For the significances of the lines on the first position in the second phase, the percentage increase was on average 16.1% (Min = -4.4%; Max = 50.1%).

From the point of view of the significance type, 66.7% of the significances were concrete (Min = 39.1%; Max = 91.8%), and 33.3% - abstract. The most frequently used words and phrases were the following: “Folded sheet” (for a complete diagonal) - 65.3%; “Signature” (for a long horizontal line placed at the bottom) - 55.8%; “Straight line for text alignment” (for a long vertical line placed on the left) - 52.4%; “Name on the exam paper” (for a short horizontal line placed at the top left) - 50.4%. The rest of the significances were below 50%.

One conclusion of the first two phases was that the lines cannot be unequivocally associated with significances. Even when the participants had to choose only from 6 significances for each line, only in the case of 4 lines (out of 18) the most frequently selected significances exceeded the value

of 50%. Obviously, a strong correlation between the line and the associated significance would have been indicated by a value higher than 90%.

3.3. Phase 3

The experiment was carried-out with 235 participants (123 female and 112 male participants). No participants from this phase were involved in the previous phases. All participants were students at a large technical university in Romania. Participants were not financially rewarded for their work. The same computer screen model was used in all work sessions.

The reliability of numerical data was tested using the Cronbach's alpha coefficient. The calculated value for the data collected using the Likert scale was $\alpha = 0.87$, value which stands for a very good reliability.

The mean of the scores awarded for the aesthetics of each line was calculated. The highest scores were: 5.47 (for the complete diagonal); 5.23 (for a long vertical line placed on the left); 5.28 (for a long horizontal line placed in the centre). The lowest scores were: 3.29 (for a short vertical line placed lateral); 2.91 (for a long inclined line placed on the side); 2.68 (for a short inclined line placed lateral). Table 1 displays the means calculated for each type of characteristics. From the table it can be concluded that a line is considered to have a high aesthetic content if it is long, placed centrally, touches two edges and is not inclined. The complete diagonal (Figure 1.b) is exactly the exception to the rule regarding the inclination of the line.

Table 1 – Means of aesthetic values of the lines deployed by types of characteristics

		Mean
Length	Short	3.72
	Long	4.20
Inclination	Horizontal	4.07
	Vertical	4.11
	Inclined	3.67
Position	Central	4.74
	Lateral	3.73
Number of edges reached	0	4.23
	1	3.53
	2	4.91

The following null hypotheses have been formulated related to the inclination characteristic:
H1: All horizontal lines are perceived the same.
H2: All vertical lines are perceived the same.
H3: All inclined lines are perceived the same.
ANOVA one-way was applied for each hypothesis, and the results are presented in Table 2. ANOVA one-way was applied for the other characteristics, with the rejection of the null hypotheses in all cases.

Table 2 – Results of ANOVA one-way for inclination characteristic

Line type	F_{calc}	*p-value*	F_{critic}	*Decision*
Horizontal	48.91	8×10^{-47}	2.22	Hypothesis *H1* was rejected.
Vertical	53.41	7×10^{-51}	2.22	Hypothesis *H2* was rejected.
Inclined	124.78	2×10^{-109}	2.22	Hypothesis *H3* was rejected.

In order to investigate the correlations between different characteristics, the decision was to apply ANOVA: Two-Factor with Replication. The null hypotheses for the position and length characteristics were as follows, and the results are presented in Table 3. The associated chart is displayed in Figure 2.

H4: The means of observations grouped by line's position are the same.
H5: The means of observations grouped by line's length are the same.
H6: There is no interaction between the line's position and line's length.

Table 3 – Results of ANOVA: Two-Factor with Replication for position and length characteristics

Characteristic	F_{calc}	*p-value*	F_{critic}	*Decision*
Position	64.95	2×10^{-15}	3.85	Hypothesis *H4* was rejected.
Length	19.95	9×10^{-6}	3.85	Hypothesis *H5* was rejected.
Interaction	135.79	2×10^{-29}	3.85	Hypothesis *H6* was rejected.

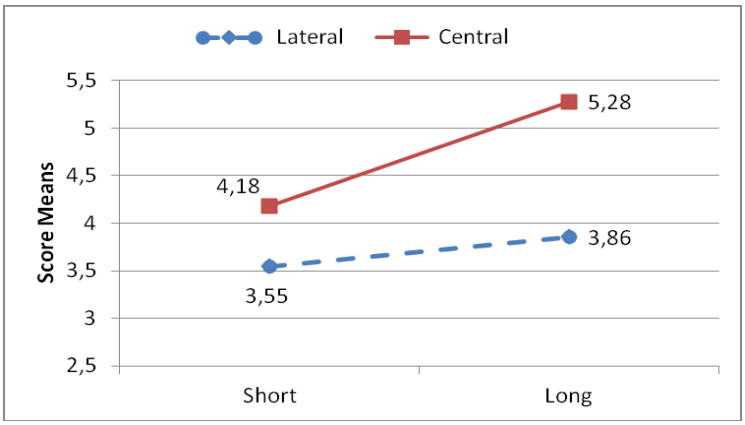


Figure 2. The correlation between line's position and line's length

The inclination and position characteristics were also analysed. (For the inclination characteristic, only the horizontal and vertical values were taken into account.) The null hypotheses were as follows, and the results are shown in Table 4. ANOVA: Two-Factor with Replication was also applied for the other combinations of characteristics, each time resulting in the rejection of the null hypotheses. The associated chart is displayed in Figure 3.

H7: The means of observations grouped by line's angle are the same.
H8: The means of observations grouped by line's length are the same.
H9: There is no interaction between the line's angle and line's position.

Table 4 - Results of ANOVA: Two-Factor with Replication for inclination and position characteristics

Characteristic	F_{calc}	*p-value*	F_{critic}	*Decision*
Position	12.41	0.01	3.85	Hypothesis *H7* was rejected.
Length	36.81	2×10^{-5}	3.85	Hypothesis *H8* was rejected.
Interaction	15.36	0.03	3.85	Hypothesis *H9* was rejected.

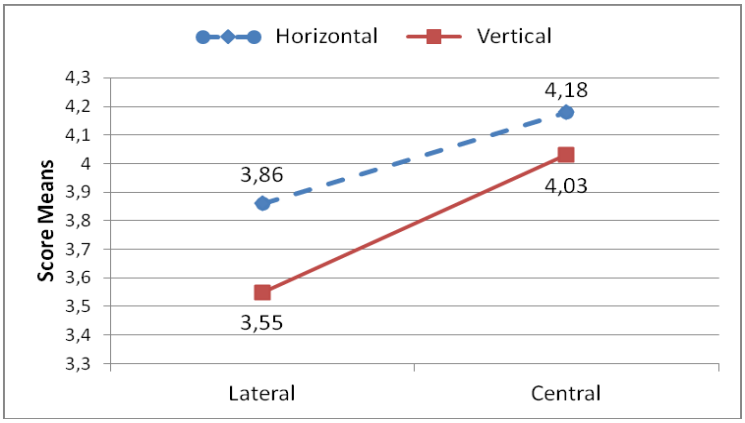


Figure 3. The correlation between line's inclination and line's position

Following the rejection of the null hypotheses in all cases, it was concluded that the aesthetic assessment of the lines was directly conditioned by the studied characteristics (length, inclination, position within the square and the number of edges reached). It was also found that all the characteristics studied interact with each other.

Each line had in the questionnaire a question related to the positive or negative attribute of the line-phrase association. 53.31% associations were assessed positive (Min = 20.43%; Max = 77.87%), and 46.69% - negative. Analysing the attribute of the association versus the primary significance of the phrase, it was found that the primary significance (positive or negative) of the phrase prevailed over the line-phrase association. Only one exception was observed, namely the long diagonal line (Figure 1.b), which, although associated with the phrase "Forbidden", was evaluated positively by 62.13% of the participants.

4. Discussion

An effective discussion about the results of an experimental research should focus on the results achieved in pursuing the research objectives. Thus, considering the initial order of the research objectives, the following aspects were discovered:
RO1. A definite significance cannot be associated with any straight line, and in the few cases in which a significance was outlined, the correlation was at most medium and by no means strong. In conclusion, it was not possible to discuss the establishment of a lexicon of line's significances that can be used in daily practice.
RO2. People encountered difficulties associating an abstract significance with a straight line. The reason was probably related to the fact that the straight line was also a concrete element and it was easier to imagine in a concrete context.
RO3. A line had a high aesthetic content (or was beautiful in a simpler and more direct language) if it was long, centrally placed, touched two edges and was not inclined. There was one exception, namely the full diagonal (Figure 1.b).
RO4. By applying statistical methods, it was found that all the characteristics of the line considered in the experiment (length, inclination, position, number of edges reached) directly conditioned the aesthetic evaluation of the straight line.
Ro5. The characteristics of the straight line interacted with each other, as confirmed by the processing of experimental data. It should be noted that the verification was made for pairs of characteristics.
RO6. People were not able to evaluate by positive / negative attributes the association between a line and a certain significance. In the vast majority of cases, the positive or negative attribute of the word or phrase could not be ignored.

5. Conclusions

The analysis of the results of the first two phases revealed the following aspects. When the participants in the experiment had to associate a given line with a significance at free choice, the chosen significances were very diverse, and the significances in the first place (after the conversion of synonyms) had percentages below 10% (with 3 exceptions out of 18).

Subsequently, when participants were able to choose from only six significances, the percentage of significances in the first place increased by about 16% (comparable to the result of dividing 100 by 6), so practically insignificant. Note that in most cases (14 out of 18), the significance of the first position has changed. Again, it should be noted that people prefer concrete significances, proof that they have difficulty imagining an abstract significance for a concrete element such as a straight line.

The conclusion of the first two phases was that a person can find a significance with a high degree of generality only for very few lines. Moreover, even for those few lines, the correlation between line and significance was medium, not strong at all.

The third phase indicated that people associated a straight line and a high aesthetic content, if the line was long, placed centrally, touched two edges and was not inclined. A notable exception was observed, namely the full diagonal (Figure 1.b), which obtained the highest score.
Another conclusion of the third phase is that the aesthetic assessment of the lines was directly conditioned by the studied characteristics (length, inclination, position within the square and the number of edges reached). It was also found that all the characteristics studied interact with each other.

Finally, it was found that in assessing a given association between a line and a significance, people failed to overcome the positive or negative character of the primary feature of the given significance.

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