INFLUENCE OF DETAILS IN PRODUCT SHAPE RECOGNITION

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The paper presents the results of an experiment carried out in order to test a hypothesis about shape recognition: offering an increasing number of details of a shape improves the ease and reliability of recognition. The authors used the photos and, respectively, contours with an increasing number of details of 12 car models to test this hypothesis. The results did not support the hypothesis, with the exception of car models with very similar overall contour.

Keywords: shape recognition, car models

1. Introduction

Experimental studies in psychology have revealed that the human perception identifies the overall shape in the first stage and afterwards the person classifies the shape. The most common type of classification is by name. Only after naming the shape, the person is focusing on details. [1]

The way a person is associating images with meanings affects the way a person is seeing the surrounding reality. If associations are ignored, the eye glance upon an object becomes the pure contemplation of its shapes, details, texture and colour. [2]

Brown and Lloyd-Jones [3] studied the recognition of faces and cars in terms of overshadowing the proper visual recognition by verbal description. They discovered that verbal overshadowing is not 'semantic category-bound'. Anyway, the verbal description is important in faces and products recognition.

Product recognition using product's contour is a focus in today's scientific research [4]. The practical applications are multiple. For example, cars are identified when entering into a parking lot. Also, statistics regarding traffic parameters can be automatically generated using car's model recognition.

Martin Krampen conducted an experiment regarding the process by which a person is recognizing the buildings. The subjects had to recognize the type of building in four stages. They saw in sequence: 1) building outline; 2) and storeys; 3) and windows; 4) and the actual photo [5]. The results of the experiment

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indicated a pattern recognition: as much details are provided, as easier is for a person to recognise the building / product.

The Krampen's experiment determined the authors of the present paper to investigate this hypothesis. They imagined an experiment in which the subjects had to recognise the precise model of a product in three stages: 1) only the bare overall contour of a product is displayed; 2) the overall contour and the contour of some large components are displayed; 3) the overall contour and all components' contours are displayed.

The participants to experiment will have to identify the product model and, also, to indicate the degree of conviction that they indicated the right model. If the Krampen's hypothesis is correct, then the participants will indicate the right model in an increasing degree as more details are displayed.

2. Experiment Design

Because the car is one of the design objects that is usually very carefully observed and assessed, the car was chosen as the subject of the present experiment. The first thought of the authors of the present paper was to take the first 12 models from a Romanian car statistics. But many cars in this top 12 were very similar and this could bias seriously the results. So, this idea was discarded.

A second thought was to take distinctive car shapes from statistics and also to consider cars with remarkable shapes even they are scarce on the streets of Romania. After several sessions of evaluation, there were retained 12 models. A pretest was organised with voluntary students and the pretest confirmed that the models possessed distinctive shapes.

The chosen models were the following:

- BMW E12;
- Corvette Coupe;
- Dacia 1300;
- Jaguar type E;
- Logan;
- Matiz M150;
- Mercedes 300;
- Mini Cooper;
- Porsche 911;
- Renault Clio Symbol;
- Trabant 601;
- Volkswagen 1300.

Logan is the most present car on Romanian streets. Statistically, there are twice more Logans in Romania than the following model. Dacia 1300 is the former national car of Romania and a significant element in 20th Century

iconography of Romanian design. The selection included popular cars (like previously indicated and also Matiz and Trabant, but also iconic cars like Volkswagen 1300 and Mini Cooper and prestige cars like Mercedes, BMW, etc.

For each model, there were searched colour photographs shot from one side. All photographs were assessed in terms of clarity, contrast and the way they highlight car's details. After a photograph was selected for each model, the photograph was given to a graphic designer to produce three types of drawings: overall contour; overall contour with the contours of some large components; and overall contour and all components' contours.

All the graphic materials (photographs and designer's drawings) were in digital format. They were grouped in four random sets (slideshows): one set with photos and three sets with drawings. In each slideshow, a single model was presented on the screen at a single moment.

In phase 0 of the experiment, the participants could see all the 12 selected photographs. Each photo was associated with the name of the model. There was no time limit for the examination of photographs. The participants were told that they will have the task to recognise the models in linear drawings, so they should focus on shapes and lines and disregard the colours in the photos. They were also announced that they will not have access to the photos during the model recognition phases.

In phase 1, the first set of contours (overall contours) was presented to the participants. They were asked to recognise the models. All the overall contours are displayed in Figure 1. As mentioned before, the participants could see only a contour at a certain moment, not all contours as in Figure 1.

In phase 2, the second set of contours (overall contours plus some large components: wheels, windshield and window frames) was randomly presented to the participants. They were asked to recognise the models. All these contours are displayed in Fig. 2.

In phase 3, the third set of contours (overall contours and all components' contours) was randomly presented to the participants. They were asked to recognise the models. All the these contours are displayed in Figure 3.

In all three phases, the participants indicated also their conviction about the correctness of their recognition. The conviction degree had on three levels: "guess", "50%" and "100%".

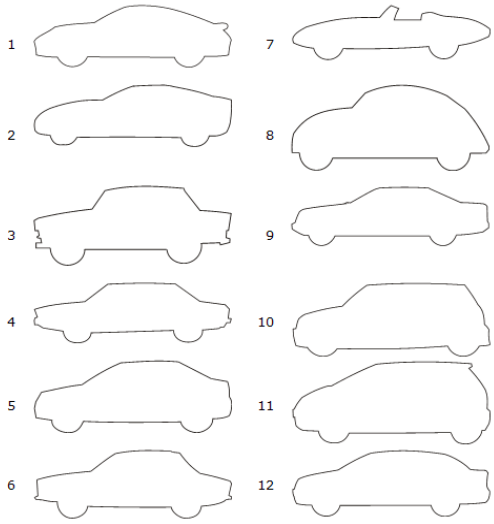

Fig. 1. Overall contours

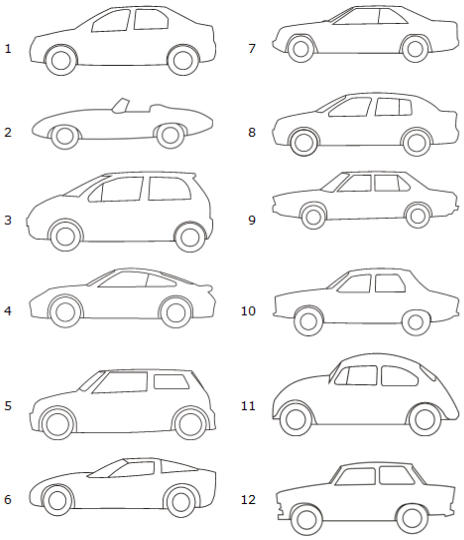

Fig. 2. Overall contours and large components

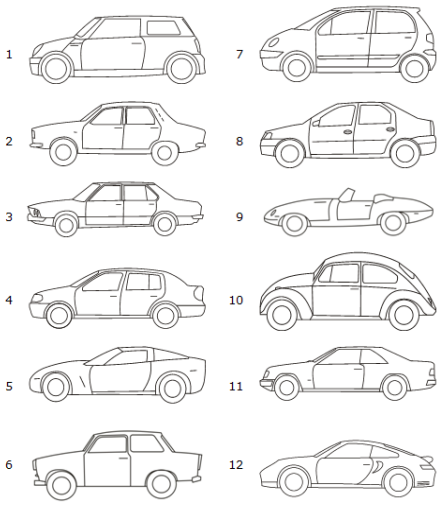

Fig. 3. Overall contours and all components' contour

3. Experimental Results

The experiment was performed with 605 participants (339 female and 266 male participants). All participants were students (age: 20 – 24 years) enrolled at a large university in Bucharest, Romania. The same computer screens were used during the entire experiment. The experiment was supervised by the authors.

The results were recorded in a spreadsheet and statistical calculations were carried out. Each type of contour has its own worksheet. The responses of each participant was recorded on a row, while the car models were on columns. A fragment of a worksheet is displayed in Table 1. In column "Correctness", the

right recognition was noted with "1", while the wrong answers with "0". In column "Intensity" [of conviction], there were registered the values of 1; 5 and 9 for "guess", "50%" and "100%". The column "C*I" is automatically calculated.

Table 1

Data registering

Model		**Mini Cooper**			
No. contour		**1**			**2**
	Gender	Correctness (C)	Intensity (I)	C*I	Correctness (C)
Participant 001	F	1	9	9	1
Participant 002	M	0	5	0	1
...	...	...	...	...	...

First, the probability of a correct recognition was calculated for each model and for each type of contour, disregarding the degree of conviction. That means all the correct recognitions were divided by the total number of tries for each model and for each type of contour.

The results are presented in Table 2, where Con1 is overall contour, Con2 – overall contour with contours of large elements, Con3 – overall contour with all components' contours, F – female participants, M – male and T – total.

Table 2

Probabilities of correct recognition (disregarding the degree of conviction)

Model	BMW E12			Corvette Coupe		
Contour	*Con1*	*Con2*	*Con3*	*Con1*	*Con2*	*Con3*
F	0,84	0,75	0,74	0,70	0,71	0,67
M	0,96	0,88	0,94	0,91	0,89	0,91
T	0,89	0,81	0,83	0,79	0,81	0,78
Model	Dacia 1300			Jaguar type E		
Contour	*Con1*	*Con2*	*Con3*	*Con1*	*Con2*	*Con3*
F	0,97	0,98	0,99	0,80	0,87	0,80
M	0,97	0,96	0,99	0,91	0,91	0,93
T	0,97	0,97	0,99	0,85	0,89	0,86
Model	Logan			Matiz M150		
Contour	*Con1*	*Con2*	*Con3*	*Con1*	*Con2*	*Con3*
F	0,96	0,97	0,95	0,93	0,96	0,97
M	0,97	0,96	0,97	0,97	0,97	0,99
T	0,96	0,96	0,96	0,95	0,96	0,98
Model	Mercedes 300			Mini Cooper		
Contour	*Con1*	*Con2*	*Con3*	*Con1*	*Con2*	*Con3*
F	0,70	0,80	0,81	0,90	0,95	0,96
M	0,91	0,90	0,96	0,94	0,96	0,97
T	0,79	0,85	0,88	0,92	0,95	0,96
Model	Porsche 911			Renault Clio Symbol		
Contour	*Con1*	*Con2*	*Con3*	*Con1*	*Con2*	*Con3*
F	0,84	0,84	0,83	0,84	0,93	0,93
M	0,96	0,96	0,97	0,93	0,98	0,98
T	0,89	0,90	0,89	0,88	0,95	0,95

Model	Trabant 601			Volkswagen 1300		
Contour	*Con1*	*Con2*	*Con3*	*Con1*	*Con2*	*Con3*
F	0,94	1,00	0,97	0,88	0,95	0,91
M	0,98	0,98	0,98	0,97	0,94	0,99
T	0,96	0,99	0,98	0,92	0,94	0,95

Table 2 allows some empirical observations regarding the positions of the car models. The first positions are shared by two types of models: a) models very popular in Romania (Dacia 1300, Logan and Renault Clio Symbol) and b) models with a very distinctive look (Matiz, Trabant, Mini Cooper and classic Volkswagen). Even prestige models, the rest scored less.

Another empirical observation is that men are better than women in recognising car models. Only in one case (1 of 36), women scored better and in few other cases the scores were equal. The differences increase in the case of prestige cars (BMW, Corvette, Jaguar, Mercedes and Porsche).

If the theory mentioned before was true, all the data would display an ascending trend; which is not the case. In some cases, some increase of probabilities was recorded, but the ratio of increase is relatively small. Quite relevant are two diagrams that display the opposite cases (Fig. 3 and Fig. 4).

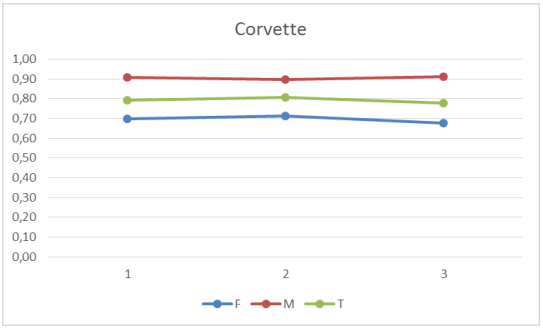

Fig. 3. Degree of recognition - constant

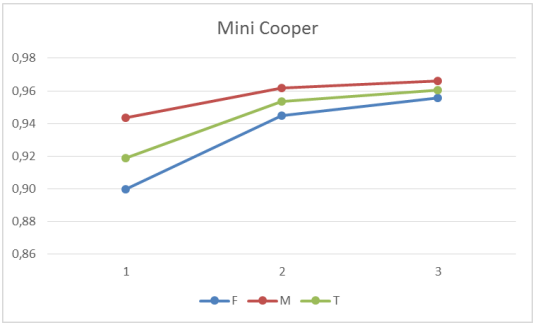

Fig. 4. Degree of recognition – dependent on degree of detailing

Considering that the above processed data does not offer a relevant result, it was decided to use the one way ANOVA technique. It started with the statement of null hypothesis that is:

H0: All the people identify the car models with the same ease, regardless of the complexity of car's linear drawing.

It was applied the one way ANOVA technique for all car models using a spreadsheet software. F_{critic} = 3.0007. The results are displayed in Table 3.

Table 3 –

Application of one way ANOVA

Model	$F_{calculated}$ (2, 1812), p<0.05	F_{critic}	*Conclusion*
BMW E12	2.036	3.0	Fail to reject the null hypothesis
Corvette Coupe	0.589	3.0	Fail to reject the null hypothesis

Model	$F_{calculated}$ (2, 1812), p<0.05	F_{critic}	*Conclusion*
Dacia 1300	0.488	3.0	Fail to reject the null hypothesis
Jaguar type E	2.023	3.0	Fail to reject the null hypothesis
Logan	0.045	3.0	Fail to reject the null hypothesis
Matiz M150	4.209	3.0	**Reject the null hypothesis**
Mercedes 300	6.628	3.0	**Reject the null hypothesis**
Mini Cooper	4.705	3.0	**Reject the null hypothesis**
Porsche 911	0.065	3.0	Fail to reject the null hypothesis
Renault Clio Symbol	10.113	3.0	**Reject the null hypothesis**
Trabant 601	2.298	3.0	Fail to reject the null hypothesis
Volkswagen 1300	1.334	3.0	Fail to reject the null hypothesis

So, the null hypothesis is true for the majority of models, meaning that giving details to the overall contour did not help the participants at the experiment in recognising the car model. What is common to the models for which the null hypothesis was rejected? What is common for Matiz M1, Mercedes 300, Mini Cooper and Renault Clio Symbol? The answer can be found in overall contours (Fig. 1). Matiz's contour is similar to Mini Cooper's and Renault's to Mercedes's.

Further it was investigated if the null hypothesis is rejected for both women and men. One way ANOVA technique was applied for the car models for which the null hypothesis was rejected and the results are in Table 4. In the case of women, $F_{critic} = 3.004$ and for men $F_{critic} = 3.007$. In both cases, $p < 0.05$.

Table 4

Application of one way ANOVA for female and male participants

Model	$F_{calculated}$	F_{critic}	*Conclusion*
Matiz M150			
Female	3.183	3.004	**Reject the null hypothesis**
Male	1.192	3.007	Fail to reject the null hypothesis
Mercedes 300			
Female	5.097	3.004	**Reject the null hypothesis**
Male	3.884	3.007	**Reject the null hypothesis**
Mini Cooper			
Female	3.334	3.004	**Reject the null hypothesis**
Male	1.747	3.007	Fail to reject the null hypothesis
Renault Clio Symbol			
Female	5.760	3.004	**Reject the null hypothesis**
Male	6.416	3.007	**Reject the null hypothesis**

From Table 4, it can be observed that basically the clues offered by increasing the degree of detailing of the contour helped both women and men.

Considering the probability of correct recognition, but also considering the intensity of conviction, each car model received by calculation a recognition mark *R* for each of the three types of contour. Obviously, the highest possible mark is 9. The results are presented in Table 5.

$$R = \sum_{i=1}^{n} \frac{C_i \times I_i}{n} \tag{1}$$

where C_i - correctness of recognition; I_i – conviction intensity; n – number of participants.

Table 5

Car models ordered by recognition marks

Model	*Con1*	*Con2*	*Con3*
Dacia 1300	8.07	8.28	**8.72**
Matiz	7.99	8.32	**8.65**
Trabant	8.02	8.37	**8.64**
Logan	8.26	8.29	**8.47**
Mini Cooper	7.58	8.07	**8.33**
Renault Clio Symbol	7.10	7.74	**8.13**
Volkswagen 1300	7.47	7.99	**8.11**
Porsche 911	7.11	7.15	**7.26**
Jaguar E	6.70	7.26	**7.25**
Mercedes 300	5.58	6.44	**7.24**
BMW E12	5.55	6.21	**6.84**
Corvette	5.93	6.05	**6.42**

At a first glance, the results in Table 5 may indicate an ascending trend according to the increase of the complexity of contours. But the application of one way ANOVA indicated that F (2, 33) = 2.023 (p<0.05) > F_{critic} = 3.285, so it failed to reject the null hypothesis. Even when the degree of conviction is considered, increasing the complexity of contours did not help the recognition.

4. Conclusions

Analysing the experimental results, it can be concluded the following:

1) The hypothesis that increasing the number of details is increasing the recognition ratio of car models was not supported by experimental data.

2) The car models are easily recognised if they are either very popular models or possess a very distinctive look.

3) Giving more details is helping in recognising very similar car models.

4) Men are better than women in recognising car models.

R E F E R E N C E S

[1]. *I. Biederman*, "Recognition by Components: A Theory of Human Image Understanding", Psychological Review, **Vol. 94**, No. 2, 1987;

[2]. *D. Pye*, "The Nature & Aesthetics of Design", A&C Black, 2000;

[3]. *C. Brown, T. Lloyd-Jones*, "Verbal overshadowing of multiple face and car recognition: Effects of within-versus across-category verbal descriptions." Applied Cognitive Psychology, **Vol. 17**, No. 2, 2003, pp 183-201;

[4]. *M. Xiaoxu, W.E.L. Grimson*, "Edge-based rich representation for vehicle classification", , Tenth IEEE International Conference on Computer Vision. **Vol. 2**. IEEE, 2005, pp 1185 - 1192 ;

[5]. *M. Krampen*, "Semiotics in Architecture and Industrial/Product Design", in volume "The Idea of Design", MIT Press, 1990, pp 89-103.