Drawing car dashboards from memory: does driving experience matters?

Vassilis Papakostopoulos & Nicolas Marmaras
papakostopoulos@gmail.com marmaras@central.ntua.gr
National Technical University of Athens
School of Mechanical Engineering, ErgoU
Heroon Polytechniou 9, Athens, Greece

The aim of the present study is twofold: (i) to explore whether the drawing from memory method is adequate to identify traces of the drivers' *operative images* for their dashboard displays panels, and (ii) to validate the hypothesis according to which the drawings of experienced drivers would be more laconic and functionally deformed than those of less experienced drivers, due to the effect of their operative images. The drawings of 335 non professional drivers are analyzed to identify persistent deformations from the actual dashboard display panels, as well as to find out differences related to the driving experience of the participants. The results show that the drivers' drawings are influenced by generic cognitive and cultural related phenomena, but also by laconism and functional deformation, reflecting therefore traces of their *operative images*. Implications of the findings for the design of dashboard display panels are also discussed.

INTRODUCTION

The scope of the study reported in this paper was to identify traces of the drivers' internal representations related to their own vehicle dashboard display panel. To this end the drawing from memory method was applied. Drawing from memory has been used for identifying humans' internal representations in various domains; e.g. to study the spatial cognition and spatial orientation abilities (Coluccia, Iosue, Brandimonte 2007), to identify the drivers' internal representations while executing complex driving tasks such as overtaking (Clarke, Ward, Jones, 1998), to study the visual world of blind people for everyday objects that are known to them by touch (Gregory, 1998) etc. However, rarely this method has been used for identifying the operators' internal representations for objects that they are confronted with on a daily basis, such as the dashboard display panel.

An objection which could be raised in using the drawing from memory method is that retrieval from long-term memory is made out-of-context. However, one may support that the internal representations of everyday things we interact with constitute elements of the *procedural knowledge* that supports performance of various tasks. Therefore, the graphical characteristics of such objects act as "external memory aids", and are not necessarily memorized as such. For example, the graphical characteristics of the various display units of a vehicle (e.g. speedometer, rpm counter, temperature gauge etc.) are rather omitted from the internal representation; it is only their status at specific moments and its meaning for controlling the vehicle that is retained in memory. In a similar way, we may lack knowledge about the visual details of common coins, but we have no difficulty in using the money (Nickerson & Adams, 1979, Norman, 1988). Consequently, asking drivers to sketch out the visual details of their own dashboard display panel out-of-context may require a kind of information organization that is not readily available to them.

Another objection that could be raised is that someone's ability to retrieve spatial location information is declined as a function of age (Chalfonte, Johnson, 1996). This may have an important implication to our study; for example, does a potential misplacement of dashboard display units from elderly drivers should be interpreted as a characteristic of elderly drivers' internal representation, or as resulting of elderly drivers' retrieval problem (Glisly, Rubin, Davidson, 2001)?

Despite these objections, there is evidence that memory of objects' location is highly depended on the inherent organization of a scene (Hirtle, Kallman, 1988), as well as that recognition memory is critically affected by domain expertise (Myles-Worsley et al 1988). For instance, Myles-Worsley et al (1988) presented to radiologists with different level of experience a set of pictorial material composed by slides of faces, clinically normal and clinically abnormal chest X-ray films, and examined their recognition accuracy. Recognition memory for faces was equally high across all levels of radiological experience. However, recognition memory for abnormal X-ray films increased with radiological experience and for the most experienced radiologists was equivalent to memory for faces. According to the authors, expert radiologists appear to process X-ray images in the same way as we all process faces, by devoting processing resources to features that distinguish one stimulus from another. Thus, selective processing of X-rays films is restricted to clinically relevant abnormalities, which are more relevant to clinical diagnosis. In contrast, less experienced radiologists, devote processing to many more variations of normal features than experts, which are not however relevant to clinical diagnosis, resulting in remembering many more clinically normal and abnormal X-rays than experts. As Groeger (1997, 105) argues, for the expert radiologist, stimuli without clinical abnormalities form, and later reinforce, notions of what schema-inconsistencies are associated with clinical abnormality. Instead, for the less experienced radiologist, who may possess less differentiated schema, many more clinically normal and abnormal X-rays will be schema-inconsistent.

The idea according to which some fundamental properties of an objects form the basis of an abstract schematic or prototypical representation, which in turns guides our processing, was first proposed by Ochanine (1968, 1970) through the concept of *operative images*. This concept refers to the specific cognition of an object, that it is developed during processing of an object related to the accomplishment of specific tasks. According to Ochanine (op. cit) *operative imag*es are distinguished in two kinds: operative images-signals and operative images-references. The former refers to the images of a perceived object or a situation that are created when the observer is guided by a specific goal or task which is related to the object. The latter refers to the images that are developed through succeeding repetitions of operative images-signals of an object or a situation, a group of objects or situations etc. In both cases, the resulting image is not an isomorphic representation of an object or a situation, but a simpler or more schematic representation that is both laconic and functionally deformed by the task requirements. Due to way that images-signals are formed, operative they are highly depended on the context through which the task is accomplished. On the other hand, operative images-references constitute the integration of the operative images-signals, dynamically enriched by them through time.

To demonstrate the concept of *operative image*, Ochanine (1971a,b) carried out a number of experiments, using among others the method of drawing from memory.

Adopting Ochanine's concept of *operative image*, we formulated the hypothesis that the *operative images* of experienced drivers would be more laconic and more functionally deformed, than those of less experienced drivers. To examine this hypothesis, we asked drivers of various experience to draw from memory the dashboard display panel of their own vehicle, and compared their drawings with the actual picture of the dashboard. However, prior to the examination of the above hypothesis, we attempted to find out whether the drawing from memory method was adequate to identify traces of the drivers' *operative images* for their dashboard displays panels.

METHOD

Participants

Four-hundred-twenty-five (425) drivers took part in this study. During analysis, however, a number of drivers' drawings was excluded due to their inoperativeness (e.g. illegible lines, use of written language, etc).

Thus, in total, a sample of 335 drawings of non professional drivers (235 males and 100 females) was selected for analysis. The drivers' age ranged from 19 to 68 years, with a mean age of 33.8 years (SD=13.7). All participants hold a driving license for at least two months, and had different levels of driving experience, ranged from 2 months to 47 years (mean=15.5 years; SD=14.3).

Procedure

Participants were asked to sketch out from memory the dashboard display panel of their own vehicle, with as many details as possible, using paper and pencil. During this process there was no intervention from the researcher and no time constraints. As far as the participants completed the drawing, they were then asked to name the drawn items, and the researcher recorded the sequence in which each item had been drawn. Finally, the following demographic data of the driver were gathered: gender, age, year of driving license acquisition, years of possession of their last vehicle and type of their vehicle.

Data treatment

At a first phase, photos and pictorial diagrams of the dashboard display panels of the participants' vehicles were searched through internet; their drawings were also scanned. Finally, appropriate files with the drawings and the actual pictures of the dashboards were developed to facilitate the analysis.

At a second phase, three independent persons were asked to compare the drawings with the actual dashboard display panel regarding their generic resemblance. A five-point scale was used to evaluate the resemblance: 1 for a lot of differences, 5 for almost similar. The majority (73%) of the resemblance scores attributed by the evaluators was identical, with the differences being no more than two points. To obtain a unique score of resemblance in the cases of disagreement, the scores attributed by the three evaluators were processed as follows. In cases of disagreement by only one evaluator, the score of the other two evaluators was gathered. In cases of disagreement among the three evaluators, then, the average score from the three evaluators was calculated.

At a third phase, the drawings of the drivers were analytically compared to the actual dashboard display panels according to the following criteria using appropriate scores.

1. *Omitted display units.* A total score for the omitted display units was calculated in the following way. The number of the drawn display units of each drawing was divided by the number of the display units included on the actual dashboard. Thus, the total score for the omitted display units ranged from 0 to 1, with 1 in the case that all display units were present in a driver's drawing.

2. *Accuracy of the relative placement of the display units.* A total score was calculated in the following way. For each display unit, a score number "0" was given if a drawn display unit was misplaced compared to its position on the actual dashboard, whereas, a score number "1" was given if there was no position alternation. The sum of the partial scores was then divided by the number of display units that were drawn. Thus, the total score for the accuracy of the relative placement of the display units ranged from 0 to 1, with 1 in the case where no alterations were observed.

3. *Relative-size-deviation of the drawn display units.* The display units were drawn in different scales, compared to their scale in the actual display panels, whereas the size of the various display units was non-identical in the actual dashboard. To obtain a measure of the relative size of the drawn display units of in comparison to their relative size on the actual dashboard display panel, we proceed in the following way.

Initially, a square was drawn to encompass the outer edges each display unit. The area of the square of each display unit was then calculated (in cm^2). The relative size of each display unit was then calculated as a percentage of its area divided by the sum of the areas of all the display units. This process has been carried for both the drawn and the actual display units of the dashboards. Finally, the relative size-deviation of each drawn display unit was calculated as a percentage of the relative size of the actual one. Thus, a +50% relative size-deviation of a drawn display unit, indicates that it was drawn twice greater than the actual one, whereas a -50% relative size-deviation, indicates that the display unit was drawn twice smaller than the actual one.

4. *Accuracy of numbering/labeling the drawn display units.* The four main display units of comprised in the examined dashboards were: speedometer, rpm counter, fuel gauge and temperature gauge. A total score for the accuracy of the numbering/labeling of each of the above display units was attributed in the following way. Each drawn display was examined according to the accuracy of the following features: numbering scale, scale intervals, units, pointers direction, and pictorial material (e.g. icons used in fuel and temperature gauges, the so-called "red zone" of the rpm counter). A "0" score was given if a particular feature was missing or it was incorrect; whereas, a "1" score was given if it was correct. The sum of the partial scores was then divided by the number of features included in the actual display unit. Thus, the total score for the accuracy of the numbering/labeling of each display unit ranged from 0 to 1, with 1 in the case of a totally accurate drawing.

5. *Drawing sequence.* It was recorded by the researcher after participants competed their drawing.

DATA ANALYSIS AND RESULTS

In this section, the results of the analysis carried out to the data is presented, aiming at examining: (i) whether the drivers' drawings provide traces of their *operative images*, and (ii) the hypothesis according to which the *operative images* of experienced drivers are more laconic and more functionally deformed, than those of less experienced drivers

Do the drivers' drawings indicate traces of their *operative images*?

To respond the above question, we focused first at the sequence of drawing the display units, and then at the relative size-deviation of the drawn display units. Before examining the sequence of drawing, the dashboard display panels were classified in terms of the spatial layout of the four main display units, namely: speedometer (S), rpm counter (R), fuel gauge (F) and temperature gauge (T).

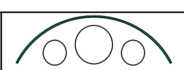
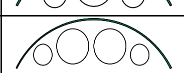
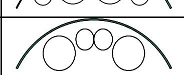
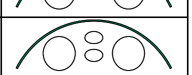
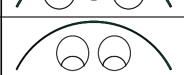
Type 1:		"S" at the center of the display panel, "F" & "T" bilateral to "S", no "R"
Type 2:		"S" & "R" at the center of the display panel, "F" & "T" bilateral to "S" & "R"
Type 3A:		"F" & "T" at the center of the display panel, "S" & "R" bilateral to "F" & "T"
Type 3B:		
Type 4:		"S"& "R" at the center of the display panel, "F" & "T" inside "S" & "R"

Table 1: Typology of display units' layouts

As it can be seen in Table 1, in our study there were four types of display units' layouts. As it can be seen in Table 1, in our study there were four types of display units' layouts.

For each type of display units' layout, the drawing sequence of the display units was then examined. Table 2 presents the drawing sequences of the display units, according to the four types of layout, indicating also their respective frequencies.

A first observation is that there exists a prevailing pattern of drawing sequence related to the size of the display units, for all the types of display units layout. That is to say, irrespectively of the spatial position of the four displays there is a clear tendency of the participants to draw first the bigger-sized displays and then the smaller ones. Consequently, we can conclude that the drawing sequence seems to be initially affected by the participants' perceptual grouping of the four display units, mainly according to their size-similarity (following the Gestalt principles).

A second observation is that the dominating pattern of drawing sequence is different in each type of display layout. For example, the left-to-right drawing sequence is the most frequent pattern in type 1 layout (38%), but the lesser one in the other three types of layouts (<14%). Similarly, the z-shaped drawing sequence that is the most frequent layout in type 2 (48%) is much less frequent in type 3a layout (5%).

A third observation is that the decision as to which one of the two bigger-sized displays, or which one of the two smaller-sized displays, will be drawn first, seems to be more idiosyncratic. For example, in type 2 displays, starting drawing the two bigger-sized displays from left-to-right has almost equal chances with starting drawing from right-to-left. The same also holds to certain point in types 3 and 4 layouts, although starting drawing from left-to-right is more frequent than starting drawing from right-to-left.

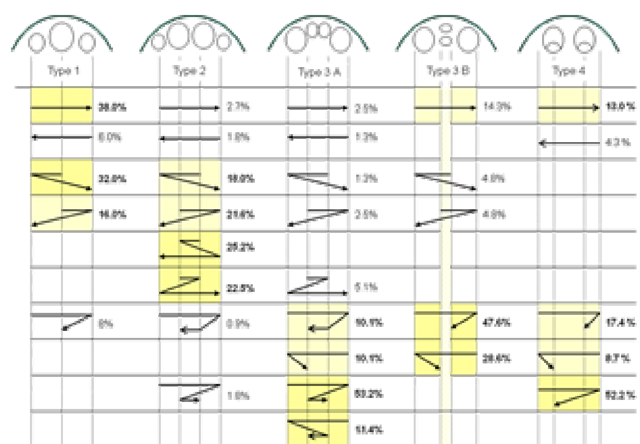


Table 2: The drawing sequences of the display units, according to the four types of layout.

Considering the above observations, we can conclude that the Gestalt principles and the cultural stereotype of western people –i.e. the left-to-right convention of writing and reading (Courtney, 1994) – seems to influence the drawing sequence of the display units. However, these two "forces" do not suffice to fully explain the observed drawing sequences. Consequently, it could be supported that the drawing sequence is also influenced by the drivers' *operative images* of their dashboard display panel (e.g. drawing first the display unit which is considered more important for the control of their vehicle).

In order to reinforce the cues for the influence of the drivers' *operative images* in the drawings they produced, the relative size-deviation of the drawn display units was also examined.

As it can be seen in Figure 1, the relative size-deviation of the drawn display units from the corresponding ones in the actual dashboard, seems to be affected by the size similarity of display units in the latter. In specific, the relative size-deviation of the first set of drawn display units (i.e. speedometer and rpm counter) is ranged between ± 5% to ±30%. This suggests a rather negligible or an almost small percentage-size deviation from the actual display units. On the contrary, the relative size-deviation of the second set of drawn display units (i.e. fuel gauge and engine temperature gauge) is ranged between: ± 30% to ±60%, suggesting a rather high size-deviation from the actual display units. Finally, the relative size-deviation of the third set of drawn display units (i.e. right and left indicator) is ranged above ±45%, suggesting a high relative-size deviation from the actual display unit.

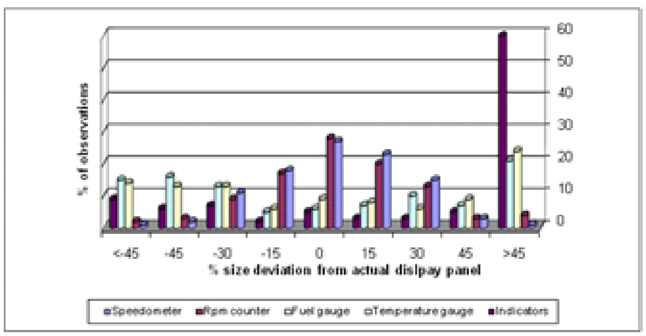


Figure 1: Percentage of relative size-deviation of the drawn display units. On the horizontal axis, negative values indicate relative size-reduction of the drawn display units compared to the actual ones; positive values indicate relative size-enlargement of the drawn display units.

However, the size similarity does not suffice to explain the observed persistent differences in the relative size-deviations between the display units of the same set, as well as the important dispersion of the relative size-deviations between the participants. Again, we can suppose that these differences are due to the influence of the drivers' *operative images* in drawing the dashboard display panel of their own vehicle.

Traces of the *operative images* of experienced and less experienced drivers

The analysis presented above, provided evidence that the drivers' drawings are influenced by their *operative images*. Consequently, we can proceed to the analysis of the drawings, in order to examine the hypothesis according to which the *operative images* of experienced drivers are be more laconic and more functionally deformed. To do this, we divided the sample of participants into three groups, according to the number of years that they held a driving license.

Table 3 presents the mean and the standard deviation values of the scores of resemblance of the drawn dashboard control panels to the actual ones, attributed by the evaluators.

	Driving experience					
	<4 years (N=114)		*5-12 years (N=104)*		*>12 years (N=117)*	
	mean	sdev	mean	sdev	mean	sdev
Evaluators' score	3.65	1.18	3.54	0.97	3,08	1.11

Table 3: Mean and standard deviation values of the scores of resemblance of the drawn dashboard control panels to the actual ones, attributed by the evaluators.

The evaluators' scores for the three groups of participants were subjected to a one-way analysis of variance (ANOVA). The variances of the scores among the three groups are statistically significant at the .05 significance level (F=8.744, p<.000). As the variances of the scores of the three groups differ significantly, a two-sample t-test assuming was then carried out to evaluate the sources of these variations. There was significant difference between the group of drivers holding their license less than 4 years (group A) and those holding their license more than 12 years (group C) (t=3.666, p<.000), as well as between the group of drivers holding their license more than 4 years and less than 12 years (group B) and group C (t=3.014, p<.003. No statistically significant difference was found between the group A and group B (t=.754, p<.452).

As it is seen in Table 3, the drawn display panels of the more experienced drivers are more "distant" from the actual ones, in comparison to the less experienced drivers.

Therefore, the hypothesis that the experienced drivers' *operative images* would be characterized by more important deformations than those of the less experienced drivers is confirmed, as their drawings are more deformed.

In order to identify the kind of deformations in drivers' drawings that are related to driving experience, the scores obtained in the following criteria were examined:

– Omitted display units;
– Accuracy of the relative placement of the display units;
– Accuracy of numbering/labeling the drawn display units.

Table 4 presents the means and standard deviations of the scores obtained by the drawings of the three groups of drivers (holding driver license <4 years, 4-12 years and >12 years) regarding the above criteria.

	Driving experience					
	<4 years (N=114)		4-12 years (N=104)		>12 years (N=117)	
	mean	sdev	mean	sdev	mean	sdev
Omitted display units	.87	.15	.87	.15	.82	.17
Relative placement	.77	.27	.82	.23	.77	.28
Accuracy in numbering/labeling						
- Speedometer	.52	.22	.53	.19	.46	.25
- Rpm counter	.42	.21	.45	.17	.40	.22
- Fuel gauge	.65	.22	.63	.22	.53	.24
- Temperature gauge	.61		.56		.52	

Table 4: Mean and standard deviation values of the scores obtained by the drawings of the three groups of drivers.

The scores of the drawings of the three groups of participants were subjected to a one-way analysis of variance (ANOVA). The variances of the scores among the three groups are statistically significant at the .05 significance level for the following criteria: omitted display units ($F=3.893$, $p<.021$), accuracy of numbering/labeling the speedometer ($F=3.521$, $p<.031$), accuracy of numbering/labeling the fuel gauge ($F=7.822$, $p<.000$), accuracy of numbering/labeling the temperature gauge ($F=2.972$, $p<.049$). The variances of the scores among the three groups of drivers for the accuracy of the relative placement of the display units and the accuracy of numbering/labeling the rpm counter are not statistically significant ($F=1.028$, $p<.359$), and $F=1.661$, $p<.192$ respectively).

The above results show that the drawings of the experienced drivers are more laconic than those of the less experienced drivers, with respect to all the criteria, except the accuracy of the relative placement of the display units and the accuracy of numbering/labeling the rpm counter.

A possible explanation of these results could be the deterioration of the ability to retrieve from memory spatial location information with age (Chalfonte, Johnson, 1996), as the more experienced drivers are also more aged. However, the results cannot be fully explained adopting this hypothesis. In fact, participants with medium driving experience (4 to 12 years) had a better performance than less experienced drivers (less than 4 years), whereas, in some respects the less experienced drivers had similar performance to the more experienced ones (more than 12 years).

Considering the accuracy in numbering/labeling the four main display units, it comes out that all three groups of participants tend to remember fewer visual details of the rpm counter in relation to the speedometer, and also, fewer visual details of the temperature gauge in relation to the fuel gauge. However, among the three groups of participants there is a variation in regards to the amount of visual details that are remembered. The more experienced drivers remember fewer visual details, whereas, the other two groups remember almost equal amount of information.

We can conclude therefore, that the less experienced drivers tend to remember better exact image of theirs dashboard display panel, but they have not developed yet a functional operative image of it. In other words, they better remember specific details of the dashboard but they lack a functional representation for integrating them. The opposite stands for the more experienced drivers. Through experience drivers they tend to develop more abstract *operative images* that are both laconic and functionally deformed.

DISCUSSION

The aim of the present study was twofold: (i) to explore whether the drawing from memory method was adequate to identify traces of the drivers' *operative images* for their dashboard displays panels, and (ii) to validate the hypothesis that the drawings of experienced drivers would be more laconic and functionally deformed, than those of less experienced drivers, due to the effect of their *operative images*.

Regarding the first goal, the drawing sequence of the display units followed by the participants, and the relative size-deviation of the display units from the actual ones, were examined. A main finding is that size-similarity of the display units affects the drivers' perceptual grouping of them. This is particular evident both in terms of drawing sequence order and relative size-deviation of the display units. That is to say, irrespectively of the spatial position of the display units on the actual dashboard, participants tend to draw first the bigger-sized displays (i.e. rpm counter and speedometer) and then the smaller ones (i.e. fuel gauge and temperature gauge). This finding suggests the importance of the dashboard display panel design to the drivers' perceptual grouping of the display units.

However, the size similarity effect do not suffice to fully explain the observed differences in the drawing sequence of the divers display units, nor the persistent differences in the relative size-deviations between the display units of the same size and the important dispersion of the relative size-deviations between the participants. Therefore, we can maintain that these differences are due to the influence of the drivers' *operative images* in drawing the dashboard display panel of their own vehicle.

As far as the hypothesis according to which, due to the effect of the *operative images*, the drawings of experienced drivers would be more laconic and functionally deformed than those of less experienced drivers, the obtained results validate it. It is worth to note here, that the observed persistent deformations are also influenced by the age-related memory effect. However, the results regarding the drivers' memory accuracy of the visual details of the display units show that, participants with medium level of driving experience (4-12 years), and therefore middle age, have better performance than younger drivers (<4 years of driving experience). Moreover, for all of participants, independently of their experience and age, there is a tendency to remember more visual details of particular display units.

The obtained results indicate that the more experienced drivers tend to remember fewer visual details, but they tend to remember, and therefore, they pay attention to specific kind of information. The latter provides a hint about the functional deformations of the *operative images* of the experienced drivers. These deformations may also be related to previous experience with various vehicle models and dashboard display panels. We can support, therefore, that the drawings of experienced drivers are reflecting a prototypical representation of a dashboard display panel rather than a representation of their current vehicle dashboard display panel.

At a practical level, the findings of the present study provide inputs for the design of the dashboards. Considering the characteristics of the persistent deformations of the experienced drivers' *operative images*, we can identify which displays and features of the dashboard display panels are essential for the drivers, and which are peripheral. This knowledge should guide the design of future dashboards, in order to be better adapted to the driver's needs, as well as to minimize eventual errors and learning effort when experienced drivers buy a new car.

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