PH-5

Role of chromo-photometry of the vehicle interior lighting in modern automotive ergonomy

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Abstract:

This work discusses the effect of the intensity colored lighting used in the car interior and its probable effect on the driver's eye performance, considering its relation with partial eye glance time. Also a proposed method to apply chromo-photometry to evaluate and enhance car lighting design on ergonomic bases

Keyword:

Car interior lighting, colored light, eye response time, eye glance time, car chromo-photometry, interior lighting design, ergonomy.

introduction:

Modern automotive industry has yield an new branch of applied engineering termed in-car design, a science that studies the design of car interior on ergonomic bases. Many literatures now are treating this subject in order to increase the safety and comfort of the driver, specially after the retreat of mechanical differences between cars, produced by most of automotive company around the world. A new problem arises when one attempts to evaluate and differentiates between two or more car of the same class or of a similar engine performance. Almost no standard evaluation method is described in this concern till the time of writing this manuscript. This work integrates many physical and technical parameters in one evaluation test, using a relatively simple procedure that eases the

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selection of the suitable car, in favor of safety and comfort of the driver and the user.

Previous evaluation attempts

Most important method used in evaluating Toyota [1] cars, relaying on what so called Ergo-index and situational suitability index
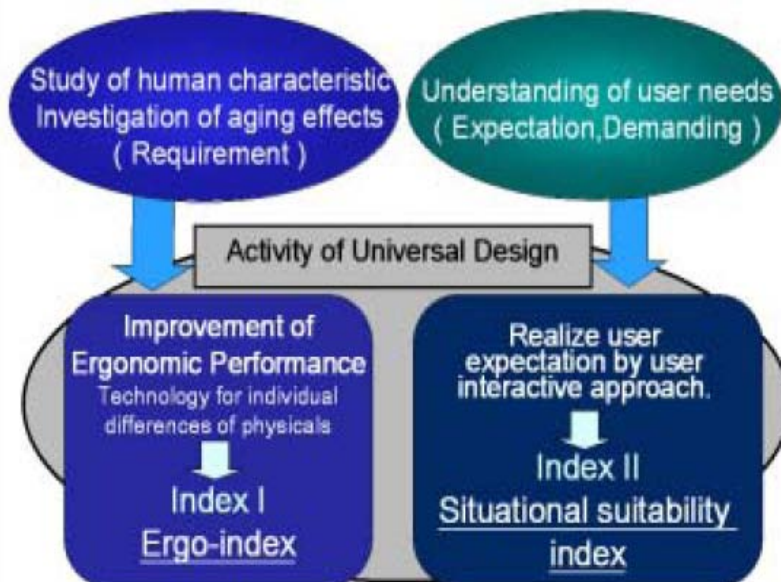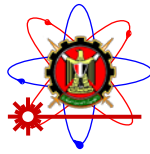

Figure 1 Toyota evaluation method

This evaluation method is very limited on the Toyota ergonomic standards to meet its marketing demands and does not take into account several issues to be discussed shortly in this work.

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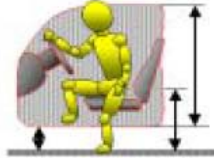
A: Example of evaluation items

Figure 2 Toyota definition of ergo-index

Factors Affecting the Evaluation Process

One can select the suitable car according to three bases namely ergonomic, economic and technical factors. These factors a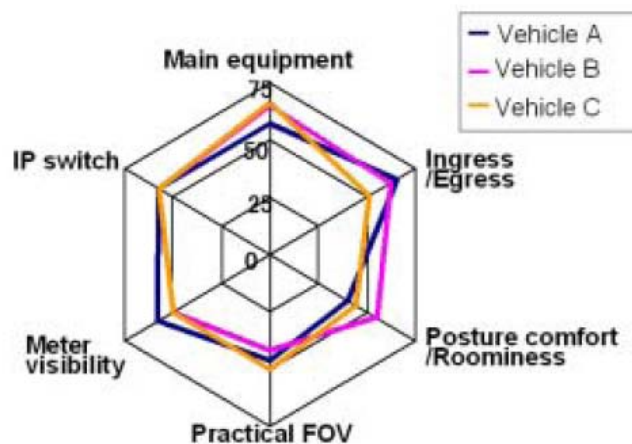re composing the evaluations criteria, that enable the examiner to favorite one design over another. Each Factor comprise many elements as shown in figure 3

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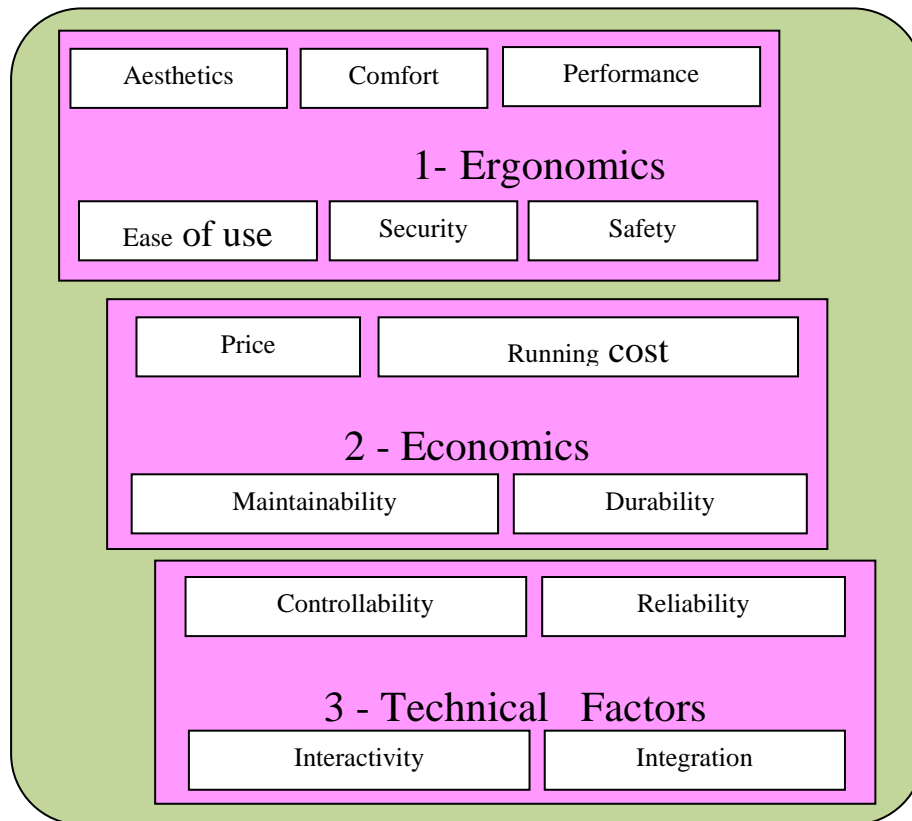**Mathematics and Engineering**
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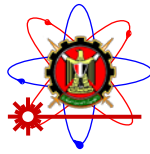
Figure 3 the basic factors affecting in-car evaluation

The previous three bulk factors (weight factors) are the framework of a novel modeling simply termed three weight (TW) model. The advantage of such model is that it integrates between many separated conceptions usually treated as independent approaches of in-car evaluation that was basically concerned in pure ergonomic point of view. According to international Ergonomics Association (IEA), ergonomics can be broadly classified into/under three definitions:

i. **Physical Ergonomics** which is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they related to physical activity. Relevant topics may include working postures, material handling, repetitive movements, work related

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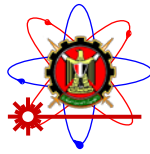musculoskeletal disorders, workplace layout, health and safety.

ii. **Cognitive Ergonomics**: A proper fit of a product to a user does not end with physical interfaces. Cognitive / perceptual ergonomics is concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. Relevant topics include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training as these may relate to human-system and Human computer interaction design.

iii. **Organizational Ergonomics**: It is concerned with the optimization of socio technical systems, including their organizational structures, policies, and processes. Relevant topics include communication, crew resource management, work design, design of working times, teamwork, community ergonomics, cooperative work, new work programs, virtual organizations, telework, and quality. management.

a major contribution is made in this work when the authors decided to include security for the first time under the definition of cognitive ergonomics, the thing that was missing before this model. Security is a major and crucial human concern that could lead to a total discomfort. We can understand security by many means:

i. The security of the driver in his car against physical and visual abuse.

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ii. The security of the driver's property, privacy and information.

iii. The security of the car and its immunity against total or partial theft trials.

Car Class according to TW model

Vehicles can be categorized according to the car's construction, engine, weight, type of fuel and emissions, as well as the purpose for which it is used.

Another standard for road vehicles of all types that is used internationally, is ISO 3833-1977. Many private enterprise and car rental companies use the ACRISS Car Classification Code to describe the size, type and equipment of vehicles to ensure that rental agents can match customer needs to available vehicles, the Insurance Institute for Highway Safety uses a scheme it has developed that takes into account a combination of both vehicle size and other vehicle features such as length and wheelbase. The United States National Highway Traffic Safety Administration (NHTSA) separates vehicles into classes by the curb weight of the vehicle with standard equipment including the maximum capacity of fuel, oil, coolant, and air conditioning, if so equipped. The United States Federal Highway Administration has developed a classification scheme used for automatically calculating road use tolls. The United States Environmental Protection Agency (US EPA) has developed a classification scheme used to compare fuel economy among similar vehicles. A similar set of classes is used by the Canadian EPA. The Canadian National Collision Database (NCDB) system defines "passenger car" as a unique class, but also identifies two other categories

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involving passenger vehicles the "passenger van" and "light utility vehicle"

Table 1 some examples of current car classification systems

Highway Loss Data Institute classification	Definition
Sports	Cars with significant high performance features
Luxury	Higher-end cars that are not classified as sports
Large	Length more than 495.3 cm (195 in) and wheelbase more than 279.4 cm (110 in)
Midsize	Length 457.3 to 495.3 cm (180–195 in) and wheelbase 266.8 to 279.4 cm (105–110 in)
Small	Length less than 457.2 cm (180 in) and wheelbase less than 266.7 cm (105 in)

NHTSA classification	Curb weight
Passenger cars: mini	1,500 to 1,999 lb (680–907 kg)
Passenger cars: light	2,000 to 2,499 lb (907–1,134 kg)
Passenger cars: compact	2,500 to 2,999 lb (1,134–1,360 kg)
Passenger cars: medium	3,000 to 3,499 lb (1,361–1,587 kg)
Passenger cars: heavy	3,500 lb (1,588 kg) and over
Sport utility vehicles	–
Pickup trucks	–
Vans	–

EPA car class	Total passenger and cargo volume (cu. ft.)
Two-seaters	Any (designed to seat onloryhy two adults)
Minicompact	Less than 85 cu ft (2,407 l)
Subcompact	85 to 99 cu ft (2,407–2,803 l)
Compact	100 to 109 cu ft (2,832–3,087 l)
Mid-size	110 to 119 cu ft (3,115–3,370 l)
Large	120 cu ft (3,398 l) or more
Small station wagons	Less than 130 cu ft (3,681 l)
Mid-size station wagons	130 to 159 cu ft (3,681–4,502 l)
Large station wagons	160 cu ft (4,531 l) or more

as shown in figure 4, the intersection of the main sets of factors of TW model can yield a new car class taxonomy that can be used to select the basic questions of the evaluation test.
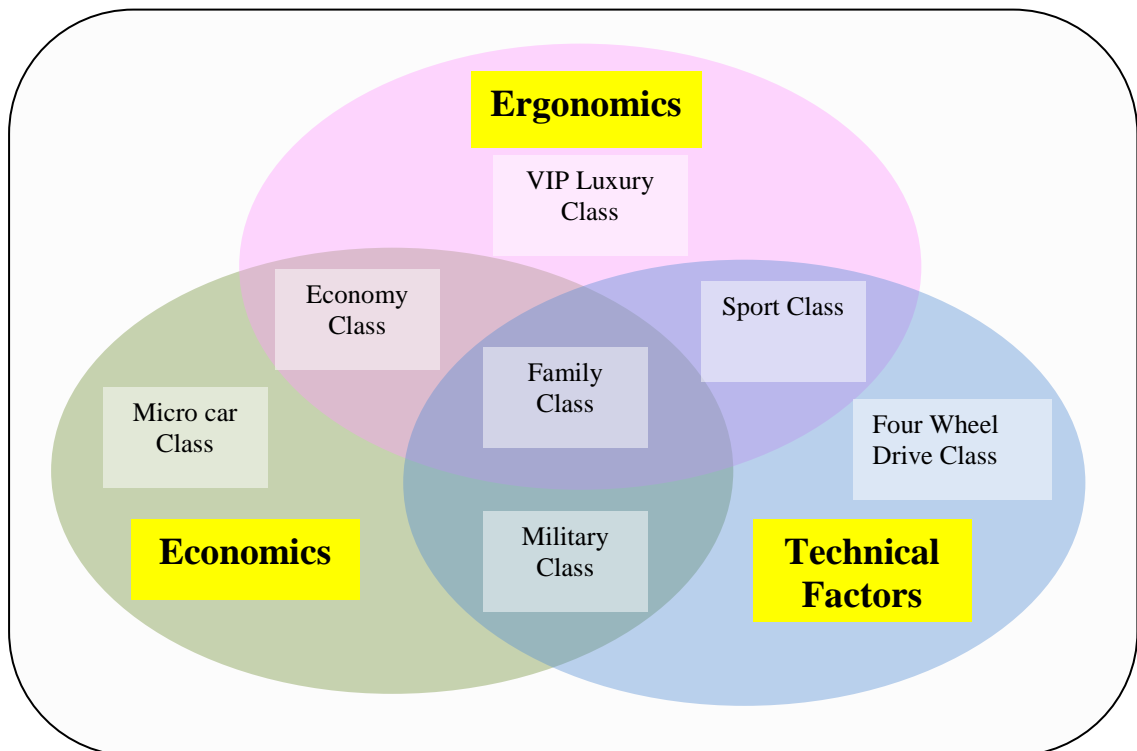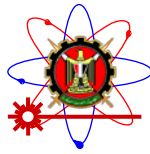
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Figure 4 New car class taxonomy based on TW model
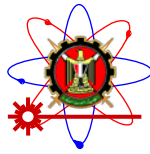
Theory and Structure of the test

Let us consider an imaginary perfect car x in the space of certain TW class, with n in-car characteristic option and another real imperfect car y from the same space, with m in-car characteristic option such that $n > m$ then:

$$I_{TW} = m/n \qquad I_{TW} < 1$$

Where I_{TW} is defined as the three weight index describing how far is the in-car design of car y from being perfect relative to car x .

n and m can be distinguished into three assembly pairs $n_{Ergonomic}$, $m_{Ergonomic}$, $n_{Economic}$, $m_{Economic}$ and $n_{Technical}$, $m_{Technical}$ or:

$$I_{NTW} = A(m_{Ergonomic}/n_{Ergonomic}) + B(m_{Economic}/n_{Economic}) + C(m_{Technical}/m_{Technical})$$

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Where I_{NTW} is the normalized three weight index, *A, B* and *C* are the weighting coefficients such that:

$$A + B + C = 1$$

It should be noticed that these coefficients must be positive numbers ranging from zero to less that one. The weight of each coefficient is selected according to the priority of the assembly in the TW class.Table 2 shows an example of proposed weighting for each class test.

Table 2 weighting coefficients vs car class

TW car class	weighting coefficients *(A, B, C)*		
Micro cars	A= 0.3	B = 0.6	C = 0.1
Economic cars	A= 0.4	B = 0.4	C = 0.2
Family cars	A= 0.5	B = 0.3	C = 0.3
VIP luxury cars	A= 0.8	B = 0.1	C = 0.1
Sport cars	A= 0.7	B = 0.1	C = 0.2
Four Wheel Drive cars	A= 0.3	B = 0.3	C = 0.4
Military cars	A= 0.2	B = 0.4	C = 0.5

It is worth to mention that this test is flexible enough as an upgradeable test to include any number of features or options in context of daily advances in modern automotive interior design by simply changing *n.*

Measuring the Non Specified Data

The vision is a crucial factor in the driving task as most of the information received by the driver come through the visual sense [4, 5]. The clear view of road (front and rear) enables the driver a safe driving. Poor visibility conditions are stressful for the drivers and results in a significantly increased risk of accident, The view ahead through the wind shield has to be sufficient and clear for the driver. It enables driver to stop

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in emergency and necessary conditions. Similarly, rear and side views are important for maintaining speed, taking turn, exerting break or during parking. On the road driver need much longer view to anticipate and prepare for avoiding actions. Views close to the vehicle is equally important when turning left or right in order to maintain proper distance to avoid accidents, therefore the test must include question about the field of view FOV. Unfortunately FOV can not be obtained from the operation manual of the car, but it has to be measured for each car under evaluation and each element of the FOV must have its own evaluation question in the test. (For example the rear and Lateral FOV, the minimum eye and neck movement ..ect).
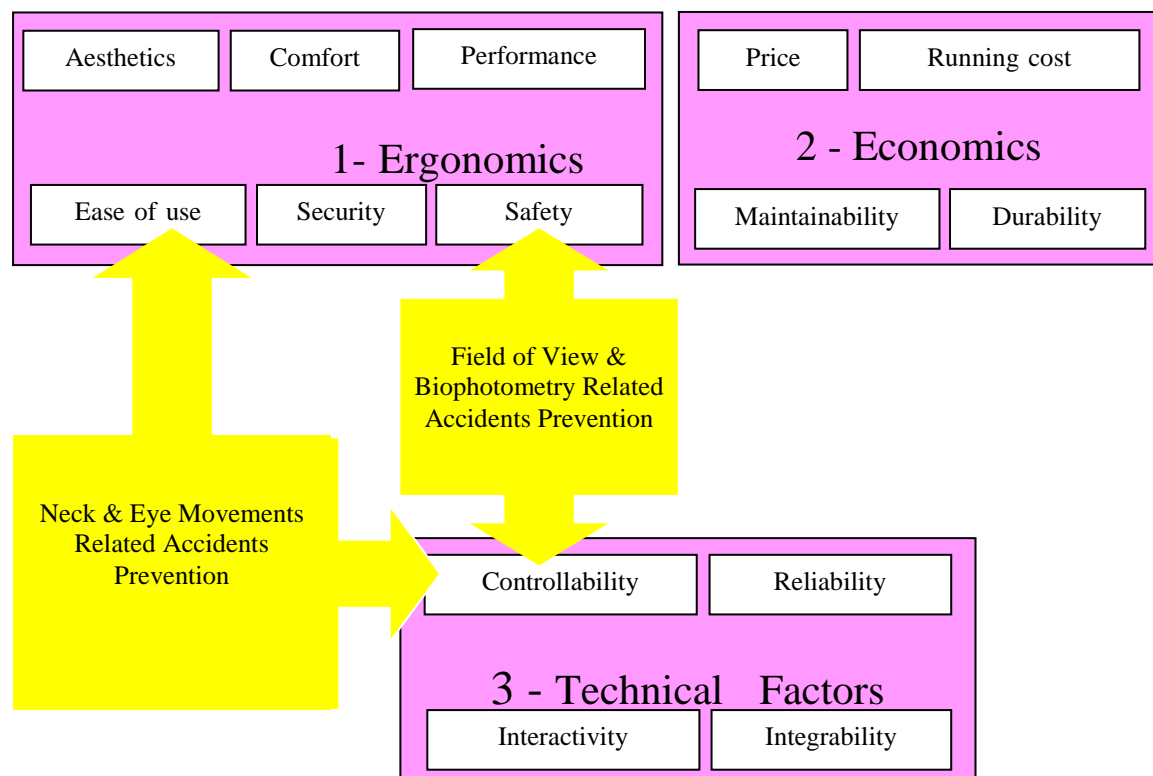

Figure 5 the essential measurement needed to tolerate the NTW index test and their position in the TW model

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Conclusion

The TW model is a simple approach that could be used easily to summarize most of the human demands when selecting a car based on its interior design, and to differentiate between cars of the same classes obtained from the mentioned model. An new concept was used to enhance the definition of ergonomy by adding security as subsidiary. The theory of in-car evaluation upgradeable test through NTW index was deduced, including the prediction of the weighting coefficients. The importance of measuring the FOV was also mentioned.

Acknowledgment

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