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Quality assessment of comfort features of Toyota vehicles

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Abstract: *The scientific research presents in a concrete and elegant way an analysis of the comfort characteristics of Toyota vehicles, as well as a qualitative assessment of them, based on comfort quality indicators and on the author's professional experience gained over a period of 40 years of driving Toyota vehicles of different types and models. This assessment will enable interested parties to find out about the quality nonconformities observed during use, which lead to a reduction in user comfort, whether they are powered by a thermal, hybrid or electric engine. The assessment covers a significant part of the range of Toyoata cars now available worldwide. In order to remedy and remove some or all of the nonconformities, the author presents his personal proposals for their correction and justifications of the causes of the problems. Also in this research are proposed and presented by the author, the most relevant indicators for assessing the quality of comfort of a vehicle. At the end of the paper, conclusions are drawn in the field addressed.*
Keywords*: vehicle, Toyota, comfort, accessibility, sensory pleasure, rating.*

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I. INTRODUCTION

Quality of comfort [1], [2] of a car has its features in the quality of the relationship between the driver or passenger and the car itself when using it, resulting in the interdependence of the ergonomic characteristics of the comfort of the beneficiaries characterised in specific circumstances of use. Recent generations of compact cars are characterised by an innovative design that gives the driver and passengers the space to feel comfortable during the journey. In addition, the interior is made from premium materials you would expect to find only in the luxury range, such as fine leather or precious wood, creating a pleasing visual and tactile impact [3]. The comfort qualities of a car can be judged using quality scales. They are not measurable quantities and are judged by the similarity of users' reactions to the comfort characteristics they have. Therefore, from the very first stage of a car's design, manufacturers need to consider these comfort qualities, in particular the design of the passenger compartment, in order to make them as attractive as possible to buyers and, not least, to be successful on the market. The parameters that determine the comfort qualities of the car cabin, which have an impact on the pleasure, satisfaction and psyche of the users, depend on comfort, accessibility, sensory pleasure, the degree or level of usability/usability, the level of usability or utility, functionality and visibility to the outside. People who are surrounded by things that provide psychological comfort can be characterised as being *"in their comfort zone"*. However, it should be borne in mind that, because of the personal nature of the positive associations that psychological comfort can have on the human being, it can take a subjective form [4].

II. THE THEORETICAL FRAMEWORK

2.1 Comfort of road vehicles

The aesthetic appearance of the bodywork is an important criterion for most users when deciding whether to buy a car. The space offered by the bodywork for different types of transport, as well as the comfort and active and passive safety provided for the driver and passengers are also very important. No less important are the mass characteristics, stiffness and aerodynamic shape of the bodywork which influence the dynamic performance, stability and handling of the vehicle [5].

The comfort of any type of vehicle or motor vehicle is defined by that state of well-being, of satisfaction, which positively influences and adds value to the physical and mental state of the users. From a psychological point of view, it is created from those passive sensory concepts, which are rooted in the spectrum of civilisation, cleanliness, comfort, peace of mind and tranquillity, making driving and travelling easy and convenient.

The comfort of a car isn't just about feeling comfortable in the seats or seats we sit in and travel in. Car comfort is also defined by those systems, installations, mechanisms and functional elements of the car that support and facilitate the work of driving (e.g. power steering, power brakes, adjustable and heated or cooled seats, electronic assistance and safety systems for the driver or passengers, electronically controlled climate control systems in different zones, sound and entertainment systems in the passenger compartment, rain and

parking assistance sensor systems, vibrations and noises produced by engines or operating parts, engine/engine power, fuel or energy consumption, etc).

According to the design specifications of an automobile, the quality characteristics for comfort must meet four criteria that are of defining importance in automobile construction:

1. The steering and control elements and components, driver or passenger seats and seats, actuating forces, distances and strokes of systems, mechanisms or components which control, move in or out of the vehicle must be properly positioned/positioned in accordance with ergonomic requirements. From this point of view, there are regulations and legislation governing these aspects;

2. Vehicle oscillations must not endanger the vehicle itself, the safety of the goods or passengers carried. Car manufacturers must take the following parameters into account when designing vehicles:

root mean square acceleration a_{rms} $[m/s^2]$, regulated by ISO 2631-1-1985/1997 [6] which sets the limit of exposure to oscillations along the three coordinate axes of the human body relative to the time norm; *amount of vibration or vibration dose Dv* $[m/s^{-7/4}]$ set for a working day at the limit of circumspection, with values of 8.5 $m/s^{1.75}$, respectively 15.0 $m/s^{1.75}$ in the risk zone; *the derivative of acceleration with respect to time (socle)* $[m/s^3]$, > +10 m/s^3, with accepted values +2 m/s^3 and comfort values of +1 m/s^3; *maximum acceleration* or *deceleration* $[m/s^2]$;

3. Vibrations and noises produced during the operation or movement of the car on the ground must not exceed a certain level;

4. The degree of heating or cooling and the humidity inside the passenger compartment must ensure optimum comfort for the driver and passengers of the car (these are regulated by SR ISO 7730:1997).

From a compositional point of view, the comfort of a vehicle is defined by several components depending on structure, operation, organisation, command, control, actuation, intuitive positioning of elements, size, appearance, composition, etc.

In this case, we can define the following components of car comfort:

- ✓ *visual comfort* - defined by colour, shapes, straight or curved lines, corners, surfaces, etc. It reflects that state of mind which formulates the satisfaction of the user (the person looking at something) with the environment they are viewing. [7, pp. 950-958]. Today's futuristic, modern-looking design and structure of the new vehicles offer impressive, high-quality visual comfort that creates maximum user satisfaction.
- ✓ *olfactory comfort* – defined by the odour emitted by the interior or exterior materials from which the car is made, but also by gases such as exhaust fumes [8]. Breathing comfort is considered acceptable when it is achieved in an environment where the air breathed into the passenger compartment of a vehicle is of sufficiently high quality. In indoor spaces (e.g. car cabs), this type of comfort can be predicted by indoor air quality (IAQ). IAQ depends on the amount of air pollutants entering from outside through the vents or open car door windows, the ventilation rate and the turnover rate of pollutants in the passenger compartment. In outdoor spaces, breathing comfort can be related to the air quality index [9, pp. 4535-4564]. To provide that olfactory customer satisfaction, vehicle manufacturers use environmentally friendly materials and paints with a pleasant, lingering smell, and vehicle-mounted catalytic converters and particulate filters stop and convert the harmful gases emitted by combustion engines into the atmosphere into beneficial gases and water.
- ✓ *vibrational comfort* – defined by the resonance of mechanical waves in the structure of the car, perceived at body level by the users, caused by rotating or translating elements of the car's organs or irregularities of the surfaces on which it runs [10]. In order to meet this qualitative customer demand, car manufacturers create highly refined cars and thermal or electric motors from reliable, durable, lightweight, dynamically well-balanced materials.
- ✓ *acoustic comfort* – is defined by noises produced by engines, rotating or translating parts, friction forces, tyre contact with the ground or friction forces of the moving car with air. Car noises are perceived by the human ear at a certain sound level, and if they exceed 80 dB, they become dangerous to human health [11, p. 7]. In the case of hybrid or electric cars, noise comfort is reduced due to the quietness of electric motors. This type of vehicle is "accused of running quietly", causing panic among pedestrians. It is therefore necessary to fit noise generators on them, which reproduce the engine noise, or other noises that are pleasant and easily perceptible to the human ear, so that they can be heard by people in the vicinity.
- ✓ *comfort to touch* or *tactile comfort* – is defined by that characteristic of the quality of the interior or exterior surfaces of a car. Comfort to the touch is determined by the quality of the materials used (e.g. the hardness of the dashboard surface, the inner faces of the doors, the hardness of the seats and the hiss when users rub against their surfaces), but also the irregularities and exterior/interior lines that define the bodywork or passenger compartment [12, pp. 216-244].
- ✓ *thermal comfort* – is defined by the temperature level inside the passenger compartment [13, pp. 1-20]. The optimum temperature and humidity set by the thermal comfort zone in the passenger compartment is very important for both the driver and other occupants of the vehicle. The optimum temperature range in the car cabin should be between 20-22˚ Celsius and the humidity should not exceed 80%. Today's new,

modern cars are equipped with air conditioning systems that automatically maintain the temperature and humidity in the passenger compartment by electronic control. In these cars, thermal comfort is achieved almost instantaneously through highly efficient electronic climate control.

2.2 Accesibility of road vehicles

Vehicle accessibility is the ability of the passenger compartment to allow the driver to make minimum and maximum natural changes or movements of body position in order to control, drive or operate the steering wheel, gear lever or other elements of the passenger compartment. As a rule, the movements and actions of the upper and lower part of the human body are always determined by the structure, size and thickness of the clothing (blouse, jacket, jacket, trousers, tie, skirt, dress, etc.), the type and size of footwear (heeled shoes, boots, sandals or slippers, etc.), other items or accessories that the driver or passengers have on them (bags, umbrellas, chains, brooches, other decorations, crutches, walking sticks, etc). From this point of view, today's cars require a limited range of movements from their users, due to their simplicity in driving, but also due to the elimination of some elements of the transmission (clutch, manual gearbox in those with automatic transmissions), by fitting a continuously variable gearbox (CVT - Continuosly Variable Transmission, as in the case of hybrid cars), or the direct use of variable speed DC electric motors in the case of full electric cars. Systems such as power brakes or power steering make it much easier to brake or steer, which reduces driver fatigue, increases driver comfort and allows the driver to concentrate more on the road and driving safely. The starting ranges of electric vehicles (DC motor produces maximum torque at any speed), or modern vehicles with powerful motors are much faster, and the power reserves are more effective and demonstrate their efficiency due to the quality of the DC electric motors which provide maximum torque/power at any speed. The qualities of high torque variation in electric vehicles are not found in cars with internal combustion engines.

2.3 Sensory pleasure of road vehicles

The sensory pleasure of a vehicle is defined by the senses, by what a human feels when touching a surface (e.g. The sensory pleasure of a car is defined by what a person feels when they touch a surface (e.g. the surface of the dashboard, door trim, seat or seat surfaces, the gloss/gloss of body paint, etc.), hear the noises of operating parts and organs that have a perceptible intensity and are pleasing to the ear (e.g. the operation of the engine, the transmission, the noise of closing doors or the boot lid, etc.), perceive the pleasant interior smell of the passenger compartment (e.g. the smell of the interior of the car, the smell of the interior of the car, etc.). the smell of the surfaces of the interior components of the cabin or of the paint coating of the car), perceives the beauty of the exterior and interior construction (e.g. the shapes and lines of the bodywork, the shape of the seats and the dashboard) and feels the comfort of the interior temperature of a living space (e.g. the air conditioning of the cabin).

This feature does not have a unit of measurement, but it has an active aspect that is based on knowledge and responds to those psychological expectations of the user who previously has a model in cognitive memory.

From a compositional point of view, *sensory pleasure* in cars has several components:

- ✓ *the pleasure to touch* – which is defined by the tactile qualities between the surfaces of the vehicle and the human body, in particular in contact with the interior surfaces of the passenger compartment elements. The influence on the human body of this type of pleasure is maximum when the duration and intensity is maximum, the pleasure being directly proportional to the type, hardness and quality of the materials from which the elements touched are made;
- ✓ *hearing pleasure* - care este definită de calitatea cu care sunt percepute zgomotele produse de elementele interioare și exterioare, de organele transmisiei sau ale propulsiei aflate în funcționare, de sistemele audio sau de entertainment, etc. What can be more pleasant than the noise of an electric motor, or a high cylinder capacity, environmentally friendly, powerful, thermal engine mounted on an electric or hybrid car, which gives maximum satisfaction to the user when accelerated and produces pleasant, consistent noises that combine power with aural pleasure, giving the feeling of supremacy, safety, satisfaction?
- ✓ *olfactory pleasure* – defined by human perception of pleasant smells. The materials, paints and textures of the interior upholstery are environmentally friendly, the covers and natural leather used in the seats and bench seats emit pleasant smells, providing the cabin environment with an odour that is pleasant to human breath and remains persistent over time. This attractive, unique, appealing look, specific to new cars, remains in the memory of every new car user, creating comfort, satisfaction, pleasure, joy;
- ✓ *visual perception* – defined by human perception of colour, harmony of shapes, lines and surfaces. Today's car models have futuristic colour shades and shapes, with well-defined and well-defined edges and lines, which create visual pleasure and comfort, are restful and delight the human eye, providing maximum satisfaction;
- ✓ *thermal pleasure* – defined by human perception at high or low temperatures of the passenger compartment interior, or when parts of the human body come into contact with the surface of car components.

Thanks to the electronics and their technology defined capabilities, electric cars achieve optimal ambient temperature parameters in a short time. This is exclusively due to electric/electronic systems, which are much more suitable, perform their functions very well and provide energy, unlike heating systems which use the fluid of heat engine cooling systems for heating. For example, an electric compressor, which runs the cooling system in the passenger compartment of an electric car, is much more efficient than a compressor driven by the belt drive of a heat engine. I believe this is due to the power and speed of DC electric motors, which is constant and stable.

2.4 The degree to which the passenger compartment of road vehicles can be used/occupied

The degree to which the passenger compartment can be used/occupied encompasses several aspects, reflecting the ability of new, modern vehicles to offer the driver and passengers the comfort of occupied positions and the optimum space required inside the passenger compartment. It states that the driver's seat and position must be standard, unique to any type of vehicle defined by the position of the steering wheel (seat or front seat, left or right, facing forward, in the direction of travel), with all controls (pedals, levers, switches, toggles, levers, levers, etc.) placed in the optimum position, to be operated intuitively, without distracting the driver's eyes from the route, and the dashboard must be placed in the driver's line of sight. The driving position must also provide the driver with the necessary space to manoeuvre the steering wheel and other controls simply, easily and comfortably, irrespective of the size of the vehicle, the position and number of other seats or interior elements, as well as optimum, correct and full external visibility, without the driver having to make a particular visual effort. Unlike the driver's seat, the other seats or benches in the car can be placed in any position in the cabin provided they offer comfort, sufficient space and maximum outward visibility. Modern cars offer all these facilities because of their small size or the elimination of certain components (bulky combustion engines, clutch and gearbox). At the same time, eliminating these parts makes them more comfortable and easier to drive and allows the driver to concentrate more on the road. However, depending on the level of equipment and automation of today's cars, a number of devices and systems intervene or support the driver, making his work easier, safer, more comfortable and more satisfying.

2.5 Functionality of road vehicles

The functionality of road vehicles is defined by the way in which the systems, devices and elements that contribute to the driving, safety and comfort of users perform the tasks and duties for which they were designed, and by the degree of simplicity and ease of access by the driver or passengers. I consider that this is provided by their efficiency and effectiveness, but also by meeting users' needs to achieve specific goals in characteristic environments.

From the functionality point of view, among these purposes/objectives we distinguish the following specific characteristics:

- ✓ *intelligibility* – defined by the quality of the messages transmitted by the on-board systems, or by the measurement and control equipment in the vehicle, but also by the ease with which the user interprets and understands the transmitted data. The level of understanding is determined by the users skills, culture, experience and professional training, intellectual knowledge of the vehicle. Modern environmentally friendly vehicles emit and display a series of sounds and messages that are easy to understand and interpret by any user. The messages are displayed in an organised, chronological, easily visible way on a tablet mounted on/in the car, which has an easy to access, understand and use touch screen menu;
- ✓ *visibility* - defined by the ease with which the user notices those stimuli arriving from the environment around him. It also derives from the ability/ability of the user of an environmentally friendly vehicle to distinguish the vehicle's elements and command and control systems. Today electric vehicles are distinguished by their ease and simplicity of driving, thanks to their electric motor(s), their driving aid and assistance systems and their level of automation;
- ✓ *legibility* - defined by the ease with which the dashboard, on-board equipment, signs, optical signals, lamps, indicia, graphic indicators and symbols on/of the dashboard can be seen by the user. As a rule, new, modern cars display large, easy-to-see symbols, numbers and letters, and the brightness of the lamps and their colour can be easily adjusted so as not to cause visual discomfort;
- ✓ *ease of touch* - is defined by the way the user can reach, touch and operate certain controls, levers, switches positioned in different areas of the vehicle cabin. It is determined by the posture and anthropometric definition specific to each user;
- ✓ *ease of operation* - defined by the simplicity of all the controls of a car. Ease of operation of mechanisms, systems, levers, pedals, switches, etc., by the user must be analysed both from an operational point of view (mode of release, pressing, gripping, number of feet, hands, fingers used, direction and direction of operation), simplicity and skill of operation (stiffness, elasticity, smoothness, etc.), difficulties encountered in operation, effort expended, distance/space required for operation by the user;

✓ *reverse feedback* – defined by the ability of automotive systems to transmit data, information or mechanical actions in response to certain actions on them by the user. Feedback from automotive systems can be *acoustic* (specific sounds easily perceptible to the human ear), *visual* (visual lights or warnings of various shapes, sizes or colours), *immediate* (perceived by the user upon full actuation which is completed by a press, movement or actuation) and *vibrational* (sensed by the user through vibrations or mechanical waves on specific parts of the body, hands or the sole of the foot).

2.6 Exterior visibility of road vehicles

Outdoor visibility of road vehicles is defined by the field of vision outside the vehicle (what the driver or passengers see outside the passenger compartment).

It is dependent on the following components:

✓ *field of direct visibility* – determined by the external environment which is viewed by people in the car through its windows;

✓ *field of indirect visibility* - determined by the external environment which is viewed by people in the car through rear-view mirrors or cameras;

✓ *visual quality* – determined by the clarity of the windows, their ability to be cleaned or wiped (especially the front window of the car) and the reflection of the dashboard lights on the front window of the car.

The research led to the following conclusion: the European Community has so far not established an explicit normative act, specific to the ergonomic problems of the driving position and the passenger compartment of motor vehicles manufactured in the Community, but the Society of Automotive Engineers (SAE) has established rules on anthropometric standards that establish links between the user-vehicle relationship (Figure 1).

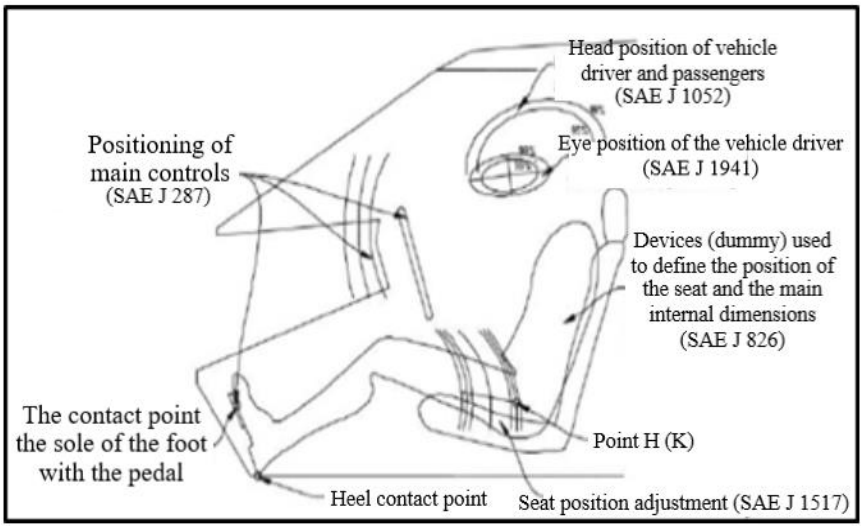

Fig. 1 SAE regulations regarding the dimensional connection between user and vehicle [17].

European car manufacturers are guided by these standards and have agreed common ECIE (European Car Manufactures Information Exchange) standards, on the basis of which standards are set specifying the defining elements of the car cabin.

In the SAE - Society of Automotive Engineers standards, as well as those agreed by the European car manufacturers ECIE, the human-vehicle relational dimensions are established. They determine the exterior and interior dimensions of the vehicle and take into account that the vehicle can be driven by people with large, medium or small anthropometric dimensions. In this case, the design takes into account the dimensions of the doors to be accessed by persons of different anthropometric sizes, the bonnet (engine and boot) and tailgate to be opened or closed and the driver position to be ergonomically optimal for persons of different anthropometric sizes. Passenger seats (seated or standing) should also be usable by persons whose body dimensions may be smaller or larger. In this regard, account will be taken of the different anthropometric sizes of people in the areas of the countries for which these cars are produced, but also of the fact that these sizes can change over time (statistical anthropometric research is carried out for car use over several decades), by establishing size parameters in percentage gradations (the notion of standard person N%, which means that of the sample of people analysed, N% represents the number of people smaller than the standard person). In this case, 5%, 50% and 95% anthropometric sizes of women and men are used.

III. INDICATORS FOR ASSESSING THE QUALITY THAT DEFINES THE COMFORT OF A VEHICLE

The quality indicators that define the comfort of a car represent the author's original conception. They are defined in accordance with the requirements of current quality standards. In the following I present three of the most important quality indicators defined by the author by means of which the comfort of a road vehicle can be defined, quantified, calculated or measured in terms of quality:

a) Intuitive positioning of controls, switches, switches, warnings and optical signals (IPCC)

The comfort qualities of a car can be judged using quality scales. They are not measurable quantities and are judged by the similarity of users' reactions to the ergonomic features they possess. This indicator assesses the positioning of all controls inside the passenger compartment of the electric car so that they can be easily operated by the user without changing the position of the body or looking away from the road.

b) Noise level produced by electric vehicles during operation/running (Lpve)

The noise produced by the engine, the rotating or translating parts, the contact of the tyres with the ground or the friction forces of the car in motion with the air defines the acoustic comfort offered to users or people in the vicinity of an environmentally friendly car. If the vehicle is dynamic (moving), the acoustic comfort is also accompanied by vibrational comfort defined by the resonance of mechanical waves in the structure of the car, perceived by the users body, caused by rotating or translating elements of the electric car's organs or by irregularities in the surfaces on which it runs. The level of noise and vibration of the motor vehicle produced during operation can be measured with specific measuring and control equipment (sound or vibration analysers). The calculation of this indicator is based on: spherical scattering reduction with adaptation of the source radiation properties to the point receivers (classical sound wave divergence); reduction factors for airborne scattering incorporation; minimum effects at ground level and defined barrier protection.

The general formula of the rules on noise level processing is defined by the relation [14] :

$$Lp = LW + 10 \lg F(r) + DI + K - Ae - Ab - Ag - Am \quad (1)$$

where:

Lp is the sound pressure, with a value of 20 microPascals;

Lw – the sound power level that can prevent from any source;

F(r) – the distance defined dimming factor;

DI – directivity index *DI = 0* (zero) for spherical radiation;

K - conversion factor of distance units to account for 10 lg 4π; K = -11 for metric units and K = -0.68 for English units;

A_e – attenuation due to atmospheric absorption (space inside the passenger compartment);

A_b – reduction by means of obstacles;

A_g – reducere prin intermediul obstacolelor;

A_m – reduction through the effect of air movements or the temperature of the environment in which the vehicle is running.

c) Level of sound emitted by audible warning devices (LSEAWD)

The level of sound created by the audible warnings of the systems in operation, emitted in the passenger compartment of the environmentally friendly vehicle, contributes to the acoustic comfort of the users and should not be loud, disturbing, especially in electric vehicles which are very quiet. The level of noise emitted by audible warning devices can be measured with specific measuring and control equipment (sound level meters). This indicator is calculated using the same calculation formula as defined for the previous indicator, except that the passenger compartment and the interior of the vehicle are taken into account, the calculation formula being as follows [14]:

$$LSEAWD = LW + 10 \lg F(r) + DI + K - Ae - Ab - Ag - Am \quad (2)$$

IV. MATERIALS AND METHODS

On the basis of comfort quality indicators, but also on the basis of the author's professional experience accumulated over a period of 40 years of driving Toyota cars of various types and models, an assessment of their comfort qualities was made. The author has driven for a long period of time (more than 20 years) a wide range of Toyota car models such as RAV 4, Yaris, Yaris Cross, Corolla, Hillux, CHR, Highlander, Aygo and Land Cruiser. The cars used in the research have conventional petrol or diesel engines of different cylinder capacities and hybrids, with different years of manufacture, and the age of the sample of Toyota vehicles used in the research ranged from 0-13 years. However, in my research I only considered Toyota vehicles with an age ranging from 0 to 10 years, as the average life of a vehicle is considered to be a maximum of 10 years, according to current legislation issued by the European Union [15]. After this age, the vehicle is taken out of service and scrapped by destruction. For an efficient and effective evaluation, we used a scale to evaluate each comfort parameter by which we gave scores from 1 to 5, associated with the quality of comfort offered by the Toyota vehicles driven, and the results obtained from the evaluation are presented below.

V. RESULTS AND DISCUSSION

5.1 Assessment of the level of comfort perceived by users of Toyota vehicles

In Table 1 I present the personal evaluation result for the perceived comfort of Toyota car users. At this time, car manufacturers no longer use curved lines/shapes of body elements. They have been replaced by lines in the form of open or sharp edges, used on all interior and exterior body elements. In this case three qualitative comfort nonconformities are presented, which I analyse in the table and justify later.

Table 1. Assessment of the level of comfort perceived by users of Toyota vehicles.

Comfort component	Score obtained					Nonconformity	The argument	Proposals/corrective measures
	1	2	3	4	5			
Vizual	-	-	-	x	-	The front side a sober, aggressive, dangerous shape.	The appearance of an open shark's mouth inducing fear, dread.	Redesign of the front design.
Olfactory	-	-	-	-	x	-	-	-
Vibrational	-	-	x	-	-	Diesel engines and the tyre profile of the Toyota Hillux and Land Cruiser transmit vibrations to the chassis and cabin.	-	Use of more elastic engine mounts or transmission components.
Acoustic	-	-	-	x	-	Diesel engines and tyre profile of Toyota Hillux and Land Cruiser transmit noise into the cabin.	-	Use of engine compartment soundproofing materials.
Tactile	-	-	-	-	x	-	-	-
Thermal	-	-	-	-	x	-	-	-

Justification of nonconformities: The front end, spoiler and radiator grille were designed and made in the shape of an open shark mouth, which gives the impression of ferocity and aggressiveness. This is a characteristic of powerful cars designed to hold supremacy in road traffic. The strong vibrations are due to diesel engines characterised by: the compression ratio of diesel engines varies between 14:1-25:1, and this is where the roar comes from, compared to a petrol engine whose compression ratio varies between 6:1 -14:1, the latter being much quieter. Cabin noises are generated by diesel engines whose ignition principle is totally different compared to a petrol engine. A high level of vibration can also be caused by the profile of the tyres fitted to off-road cars. It is noted that, in order to ensure efficient and effective grip and traction, the tyre profile on these offroad vehicles is of the *"tractor"* type, made on the tread of the tyres by means of studs which, on contact with the road, produce high noise and vibration. The noises are transmitted into the passenger compartment and are strongly perceived by the users.

5.2 Assessment the level of accessibility, body position and access to controls of Toyota vehicles

Accessibility in a car is very important. It refers both to the access of the driver and passengers to the car through the space provided by the opening doors, but also to the way in which the car seats ensure optimal comfort and proper body position, allowing easy access to all controls without changing the position of the human body. Table 2 shows the author's assessment for accessibility, body position and access to controls of Toyota vehicles, for which only one qualitative comfort nonconformity was identified, which I analyse in the table and justify later.

Table 2. Assessment of the level of accessibility, body position and access to the controls of Toyota vehicles.

Comfort component	Score obtained					Nonconformity	The argument	Proposals/corrective measures
	1	2	3	4	5			
Access into the vehicle	-	-	x	-	-	The upper part of the right/left access to the front and rear bodywork seats is too low in relation to the seat height of the saddlebags.	A driver and a tall, burly passenger bump their heads against the top of the body frame as they enter the front seats.	1. Reducing the seat height of the front seats; 2. Change in the height of the access areas on the front seats of the vehicle.
Body position	-	-	-	-	x	-	-	-
Access to commands	-	-	-	-	x	-	-	-

Justification for nonconformities: In cars such as RAV 4, Yaris, Yaris Cross and Corolla Hatchback, drivers and passengers with taller or higher body mass indexes have heavy access to cars. Tall people say they bump their heads when accessing vehicles on the upper body frame. This is also confirmed in the survey by passengers

accessing the rear seats of Toyota CHR cars. The majority of full-bodied passengers who accessed the rear seats of the Toyota Aygo, Yaris and Yaris Cross said that they did not feel comfortable in the rear seats of these cars because the space was too tight (three such passengers could hardly fit in the rear seats) and the legroom was reduced by the front seats. This makes them uncomfortable.

5.3 Assessment of the sensory pleasure level of Toyota vehicles

The sensory sensory pleasure level of Toyota cars is defined by the satisfaction the user feels when touching the surfaces of the vehicle's components, the noise produced by the combustion engine or electric motors (some hybrid variants have two electric motors and one combustion engine), the smell of body paint or materials used for seats, door upholstery, floor or roof carpeting, interior floor mats, etc. What the user sees and feels, the shape of the body and its elements, the interior warmth provided by the air-conditioning system, the way and the ability of the interior elements to provide quality comfort to the touch are all defining factors in the user's evaluation of the body. Table 3 shows the personal assessment of this type of vehicle in terms of the sensory pleasure offered. Two qualitative comfort nonconformities are identified, which I analyse in the table and justify later.

Table 3. Assessment of sensory pleasure level of Toyota vehicles.

Comfort component	Score obtained					Nonconformity	The argument	Proposals/corrective measures
	1	2	3	4	5			
The touch	-	-	x	-	-	The sides of the front centre console are too hard.	Discomfort to touch.	The use of soft materials similar to those on dashboards or door padding.
Hearing	-	-	-	-	x	-	-	-
Olfactory	-	-	-	-	x	-	-	-
Visual perception	-	-	-	-	x	-	-	-
Thermal pleasure	-	-	-	x	-	Black leather seat and bench surfaces. They get very hot in summer and very cold in winter, creating thermal discomfort to the touch.	Due to the variable outside temperatures, the rear seat and bench surfaces get very hot in summer at high temperatures and very cold in winter at low temperatures.	Use of other materials with low heat absorption (e.g. natural skin-like material).

Justification for nonconformities: All low cost variants of the Japanese manufacturer Toyota, have dashboard, console and door inner panel surfaces made of a hard plastic material, which creates discomfort to the touch. Only the mid range and top of the range variants have these surfaces covered with artificial leather, natural leather or textile material, which produce a particular sensory pleasure to the touch. In contrast, medium and top variants whose seats or benches are covered with artificial leather or natural leather produce thermal discomfort in summer, when they are strongly heated by the sun, or in winter, when they are extremely cold from low temperatures. These thermal discomforts are resolved as quickly as possible by the efficient and effective use of heating or cooling systems for seats or bench seats.

5.4 Assessment the extent to which the passenger compartment of Toyota vehicles provides optimum conditions for use

In this case, it accurately reflects the ability of this modern car to provide users with the comfort of occupied seats and the optimum space required inside the cabin, with the lack of this for the legs of rear seat occupants in smaller Toyota cars (Aygo, Yaris, Yaris Cross) and access to certain controls via buttons positioned at the base of the dashboard. The extent to which the passenger compartment of motor vehicles can be used is analysed in Table 4. From this point of view, only one qualitative nonconformity of comfort was revealed by the assessment, which I analyse in the table and justify later.

Table 4. Assessment of the extent to which the passenger compartment of Toyota vehicles provides optimal conditions for use.

Comfort component	Score obtained					Non-conformity	The argument	Proposals/corrective measures
	1	2	3	4	5			
he comfort of the driving position	-	-	-	-	x	-	-	-
Front passenger seat comfort	-	-	-	-	x	-	-	-
Comfort of the rear seat	-	-	-	-	- x	-	-	-
Optimum space required at the front	-	-	-	-	x	-	-	-
Optimum space required at the rear	-	-	x	-	-	-	-	-
Pedal access	-	-	-	-	x	-	-	-
Access to the steering wheel	-	-	-	-	x	-	-	-
Access to the gearshift lever	-	-	-	-	x	-	-	-
Access to on-board controls	-	-	-	x	-	Visibility to the control switches on the lower left of the dashboard is obscured by the steering wheel spokes.	Tall board; Control switches for important systems located well below the field of vision or obstructed by steering wheel elements.	1.Reposition the switches in an easily accessible area on the dashboard of the car; 2.Reconfiguring the steering wheel spokes.
Visual access to the dashboard	-	-	-	-	x	-	-	-

Justification for nonconformities: The majority of respondents say they do not feel comfortable in the back seat of the Aygo, Yaris, Yaris Cross (low range cars) due to reduced legroom and side space (three passengers in the back seat are very cramped). Access to some controls via on-board buttons: this is particularly noticeable on the RAV 4, Hilux and Land Cruiser (SUV variants). Switches to operate certain controls (e.g. Automatic shortcut phase on the RAV 4, electric fuel filler opening on the RAV 4, heated steering wheel on the RAV 4, and panoramic view via cameras on the Toyota RAV 4). To access these buttons, which are at the bottom left-hand side of the dashboard, users have to lean to the side to operate them, which distracts drivers from the road. Another aspect of the controls reported by respondents is the visibility of the illuminated indicators on the power window open/close buttons and other controls on the vehicle doors. These buttons are not illuminated at night on most models, making their operation intuitive rather than visual (poor visual distinction). This too causes discomfort and distracts drivers from the road.

5.5 Assessment of the level of functionality of Toyota vehicles

The functionality of Toyota vehicles is defined by the way in which all systems, devices and elements fitted by the manufacturer contribute to safe driving, ensuring maximum user comfort. They perform their intended tasks and duties properly. The degree of simplicity and user-friendliness of access to all of them is shown in Table 5. From the analysis carried out, it appears that all the ergonomic components achieved a maximum score and no qualitative comfort nonconformities resulted.

Table 5. Assessment f the level of functionality of Toyota vehicles.

Comfort component	Score obtained					Non-conformity	The argument	Proposals/corrective measures
	1	2	3	4	5			
Intelligibility	-	-	-	-	x	-	-	-
Visibility	-	-	-	-	x	-	-	-
Readability	-	-	-	-	x	-	-	-
Ease of touch	-	-	-	-	x	-	-	-
Ease of operation	-	-	-	-	x	-	-	-
Feedback	-	-	-	-	x	-	-	-

All ergonomic elements of functionality were rated with maximum score by respondents. This reflects a high degree of ease of understanding of the functionality of Toyota vehicles by users, but also the response (feedback) returned by the driving, command and control systems of Toyota models' autonomy.

5.6 Assessment the level of outdoor visibility of Toyota vehicles

Toyota's interior elements, the windscreen, rear window and rear windows, allow generous exterior visibility. Analysis of this ergonomic component revealed no qualitative deficiencies in terms of comfort. Table 6 shows the analysis.

Table 6. Assessment of the level of outside visibility of Toyota vehicles.

Comfort component	Score obtained					Non-conformity	The argument	Proposals/corrective measures
	1	2	3	4	5			
Field of direct vision	-	-	-	-	x	-	-	-
Field of indirect vision	-	-	-	-	x	-	-	-
Visual quality	-	-	-	-	x	-	-	-

The visual quality of Toyota vehicles is also supported by visual and acoustic or visual warning systems (Blind Spot Monitoring - BSM and Rear Cross Traffic Alert - RCTA), which are currently fitted to the Japanese carmaker's top models. I propose that these systems should be included in the Toyota Safety Sense package, so that they can also be fitted to the base models, which are the most numerous at this time. From the point of view of passenger safety and road traffic safety, Toyota vehicles have been equipped, even from the basic version, with the Toyota Safety Sense package, which now has six new active safety technologies. Toyota Safety Sense includes a range of advanced technologies: Pre-Collision System, Lane Departure Warning, Lane Keeping Assist, Traffic Sign Assist, Automatic High Beam, Adaptive Cruise Control - with the ultimate goal of reducing traffic accidents as much as possible, helping to create a safe driving environment for everyone, taking care of drivers on their daily journeys [16]. Safety Sense helps prevent dangerous situations [16]: Pre-Collision System uses camera and radar to track vehicles ahead, helping to avoid or mitigate collisions; Lane Departure Alert warns when the car crosses the lane unintentionally; in addition, Lane Keep Assist helps keep the car in the centre of the lane with minimal effort, being able to track the vehicle ahead and its trajectory. Automatic Long Phase switches between Long and Short Phase for safe night-time travel; Traffic Assist displays traffic signs on the information screen and can even suggest new speed limits for Cruise Control. All Toyota vehicles have a high driving position (driver's seat height adjustability), so all drivers can see the front and engine hood from the inside. This makes it easier to fit the vehicle into the road lane.

VI. CONCLUSIONS

The assessment of the comfort level of Toyota cars was based on a questionnaire in which 250 respondents who use the brand in Romania participated.

Globally car manufacturer Toyota ended 2023 with record sales figures. The Japanese automaker built 9.23 million vehicles and sold 9.36 million vehicles. The models sold by the Japanese manufacturer Toyota vary from one continent to another. They are tailored to the needs of the market, so that in Europe some are more successful than in other parts of the world. Toyota's sales in Europe grew by 2.5% in the first part of 2023, giving it a 6.9% market share and consolidating its position as the second best-selling car brand on the old continent. In Romania, Toyota sold 768 units in 2023 (+29% compared to 2022), (classic, hybrid and electric vehicles). Toyota cars are known for their reliability all over the world, as the Japanese manufacturer has a long history of building reliable vehicles and its models are consistently ranked among the best on the car market. Numerous surveys have been conducted over the years, and Toyota models were the ones with the smallest drops in reliability and maintainability. This has remained true in 2023. People who buy Toyota cars also do so because they are very safe. The Japanese manufacturer has a long history of investing in safety research and development, and its vehicles consistently earn top marks for safety.

The qualitative comfort related nonconformities of Toyota vehicles in this research may affect the safety in operation of these vehicles which, in the author's view, were not reported, or were reported and yet accepted by the manufacturer. He considered that these elements did not constitute or create a high degree of discomfort and were probably accepted because the technical conditions for placing or fitting the elements (e.g. buttons, switches) or phenomena (e.g. excessive heating or cooling of seat surfaces) in a different location from the one actually existing did not exist. To correct these, the manufacturer has developed systems to heat or cool the vehicle seats, correcting this non-conformity, the discomfort being minimal and limited in time. In this respect, I consider that in order to create optimum conditions of comfort when using the seats, the manufacturer should have provided for an automatic instant cooling system for all seats and bench seats whose surface is covered with artificial or synthetic leather for all models using this type of upholstery for the surfaces of the seats.

The centre console surface elements are too hard and uncomfortable to touch. They could have been made of the same materials as the dashboard surface or the interior door padding (ecoleather or natural leather cover). If it is not possible to use natural leather, which is expensive at this date, a scratch resistant or mechanically resistant artificial

leather could be used. Vehicle quality indicators are defined by how well a car meets the expectations of the driver (user or owner), customer or passenger (beneficiary of the transport service) within a defined timeframe.

Vehicle quality indicators are defined by how well a car meets the expectations of the driver (user or owner), customer or passenger (beneficiary of the transport service) within a defined timeframe.

In this case, the time period can be interpreted as: the entire life cycle of the car, the period of ownership of the car by the owner, a journey on a given route or itinerary, a carriage of goods or passengers, the period of loan or hire of a vehicle.

The comfort qualities of the car, the assistance systems, the driver's communication systems with the car and the traffic, the passenger information systems are just some of the features used to assess the quality of the road transport system. When these features are added to the environmental qualities of hybrid or electric cars, characterised by low or zero tailpipe emissions and quiet operation, the car fully meets the implicit and explicit needs of the user.

The car is the key element of the road transport system. It is both the driver's place of work and the means of transport for mobility and the movement of goods or passengers. Over time, technology will evolve and car driving systems will provide full autonomy. In this case, the need for the driver to control the driving will disappear, making him a simple passenger in the autonomous vehicle.

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