Guidelines Passenger Cars for Seniors: Requirements

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ABSTRACT

The article describes a significant diversification of the motor vehicle market. It outlines factors facilitating and hindering seniors’ access to cars by referring to typical vehicle operation processes. A number of problems related to the selection of products better suited to the needs of seniors are signalled. An example of the author’s checklist supporting senior citizens with an informed choice of necessary and available options and features of series-produced cars is given. The work indicates the possibilities of using additional vehicle equipment and assistive technology enabling or supporting the driving process.

INTRODUCTION

A passenger car is probably one of the most important long-term consumer goods [1]. The possibility of using this technology at every stage of human life is, for many individuals, the basis for maintaining an active life at a sufficiently high level. This is particularly important for older people, whose possibilities of independent movement without using technical solutions are very low [2]. The ability to drive a motor vehicle, in this case, makes it very easy to travel independently without involving third parties, which is very important for seniors. In order to preserve this ability, technical solutions used by seniors must be appropriately adjusted to their needs. Assistive technology and rehabilitation engineering required for car adaptations should be selected based on the specific needs of seniors and/or older passengers.

As the number of older people has been rapidly growing in recent years, vehicle manufacturers are increasingly interested in this target group. Therefore, the direction of automotive development dedicated to older people will have to be based on the study of the relationships between a driver, a car and the surroundings.

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FACTORS FACILITATING AND HINDERING ACCESS TO CARS FOR SENIORS

Contemporary technical development often does not take account of the needs of older people. Technical innovations usually ignore this target group through their complex functionality, inadequate user interface, design and marketing. Therefore, older people neglect new technologies, pointing out that they are too complex and unrelated to their basic life needs. Thus, reducing the number of available functions and increasing the usability of products is the right direction for the development of technical devices for seniors. At the same time, modern trends in the development of sophisticated technologies for seniors indicate that the elderly person’s life will be easier thanks to a range of new solutions, such as: intelligent products, systems for navigating through cities, innovative hearing and visual implants and memory support products [3]. A good design solution for the elderly must take account of a certain conservatism, resulting from experience and a general understanding of new products. The lucrative car market for older consumers (the segment of expensive and luxury cars) is an example of how difficult it is to introduce changes [4].

New design solutions for safety and comfort available in many modern cars can help compensate for the age-related dysfunctions of their users. Advanced car interior solutions help reduce the annoyance caused by a loss of height, mobility problems, arthritis and other causes of pain. Significant variations in dimensions and quality classes, and a very wide range of vehicle retrofits from different manufacturers, make it easy to select a car according to the size of the human body and utility preferences.

When assessing car adaptations for the needs of seniors, the following activities involved in the vehicle operation process should be considered: driving, getting in and out of the car, operation. Typical modern conveniences supporting the driving process and ensuring active and passive safety include: a rear-view camera; highly contrasting dashboard signalling devices; automatic change of dashboard backlight from daylight to nightlight; larger dashboard controls; larger audio and control elements on the centre console, such as air conditioning (clear signs, large letters); heated seats; seat geometry adjustment including lumbar support (manual or electric adjustment in luxury cars); large ranges for seat adjustment; thick-rimmed steering wheels; automatic gearboxes; assisted driving systems to control directional stability, adhesion and braking; a large number of airbags; flexible and adjustable interior; good side seat support; blind spot monitoring system; air filter in the car cabin; loudspeaker system; automatic parking system; adjustable pedal positions; large windows; keyless ignition system; and responsive steering system.

The process of getting in and out of the car is influenced by a number of features related to the dimensions and geometry of the body and interior of the vehicle [9]. The most serious problems encountered by seniors include stepping over the door sill, getting in or out of the seat, opening the door when getting out, the wrong position of the steering wheel when getting in, and the low position of the upper edge of the door opening when getting in. These problems result from the need to perform the so-called difficult moves when handling various devices and the fact that some high-tech products do not meet the needs of older drivers with age-related disorders.

Performing other vehicle operation activities may be supported by other systems, such as: remote keyless entry system, hands-free entry system that unlocks the door automatically when the owner approaches the vehicle, capless fuel system, entertainment system and voice activated navigation system.
The functions that are currently used in cars are designed for a broad target group. In many cases, however, they prove to be more useful for older people, for whom they may be indispensable, than for younger people, who treat them as features that only increase comfort. Some of these systems may be necessary for seniors to maintain safety and even to operate a vehicle.

THE VARIABILITY OF CAR FEATURES AND THE POSSIBILITY OF INDIVIDUAL ADAPTATION

The purchase of a car, involving the choice of its size and body type, depends primarily on the personal preferences of the user, but should also take account of other, more objective requirements. When making decisions, seniors can often be guided by well-known stereotypes, such as that large cars are more secure and small ones are easier to drive. A great convenience in choosing a vehicle according to individual expectations and purposes is the division of vehicles into segments (A and B segments—city microcars; C segment—small family cars; D segment—large family and compact exclusive cars; E segment—exclusive cars; F segment—luxury limousines with the highest level of equipment; G segment—sports cars; H—convertibles; I segment—sport utility cars; K segment—vans). This is only one of many existing divisions of passenger cars. Cars manufactured as part of individual segments by different manufacturers can also be characterised by considerable diversity. Other selection criteria may include available car body types (e.g. sedan, hatchback, liftback, station wagon, van, SUV, cabriolet) and the number of doors (2, 3, 4 or 5-door cars). Both the equipment and dimensions of vehicles may prove to be important due to the expected comfort and safety of their use. Vehicle development in recent years also confirms another trend, namely, the newer a model by a given manufacturer in a particular segment is, the larger interior dimensions can be expected. Thus, when presenting the variability of car features, one must take account of their division according to comfort and luxury. The more luxurious the cars are, the greater the number of options and modern comfort and safety solutions they have. However, this may lead to an excess of available functions causing discomfort when used by older people.

A specialist-advisor may support the vehicle selection process made by an elderly person by prompting what advantages and disadvantages resulting from the constructional variability of parts and systems fulfilling the same functions are, what their impact on the vehicle handling is and what the main rules of their application are. An exemplary list of those related to getting into and out of the vehicle, conducting and carrying out other handling activities is indicated below. This set includes:

- the doors: narrow swing, usually well-fit doors in a 5-door car (possible entry problems); wide doors in a 3-door car (difficulties with closing, take up more space, usually more convenient to get in); the height of the door opening (the higher it is, the more comfortable it is to get in and out of the car); sliding doors (a large force is usually required to open the door, easy to get in); scissor doors (standard hinges are replaced with hinges at which doors rotate vertically, easy to get in—minimise entry problems); other;

- the seat: shape and position (a flat seat facilitates getting in backwards in the car, but it adversely affects stabilisation while driving; adjustment of lumbar support increases comfort) and position (a low seat makes it difficult to get out of the car,
higher seats can make it difficult to get in, but are usually more comfortable; adjusting the seat depth and seat inclination angles; and using additional cushions, replacing standard seats with specialised seats from other manufacturers (e.g. Recaro seats, bucket seats, seats with adjustable thigh support, seat extensions enabling adjustment to individual needs—the solution is used in luxury cars); seat adjustment knobs, levers and buttons are placed within reach and are thus easy to turn on; the height of the seat should be correlated with anthropometric dimensions, such as height, popliteal height); options (electric position adjustment facilitates use, heating increases comfort), electric seat adjustment facilitates the adjustment process as manual adjustment might be too effortful;

- **additional adaptation solutions**: they are not part of the car's standard equipment (seat turntable, additional holders attached to the B-pillar lock or attached to the door; a mechanism for pulling the seat out of the car—makes it easier to get in and out of the car).

When driving a car, the following are important:

- **the handbrake**—the position and shape of the lever (standard lever, automatic or pulled using a button placed on the dashboard or at the gear lever; mechanical or electrical; pulled automatically when stationary or operated with a button located anywhere in the car; handle shape adapted to the user’s force);

- **the steering wheel**—adjustable in two planes, the force needed to turn the steering wheel adjusted to the user’s needs, variable power assisted steering depending on the speed, cross-section of the handle, diameter of the steering wheel;

- **the gearbox**—automatic, sequential, manual; gear selector under the steering wheel or on the dashboard; a cruise control system; a system ensuring a constant distance between vehicles;

- **the accelerator, brake and clutch pedals**—reachable after adjusting the seat, appropriate pressure force, adjustable position of the pedals;

- **other devices**—central locking system; electric windows; mirrors; heated mirrors; heated windshield; twilight sensors; rain sensors; headlight wipers; audio equipment activated by voice or buttons on the steering wheel; GPS voice navigation; reverse video camera; panoramic rear-view mirrors; additional handles; change of seat belt attachment (safety belts extended on the handle as in cars from the USA); various knobs and levers (e.g. a lever for turning on the turn signals and wipers), their shape, position and forces needed for switching on.

When operating a car, the following are important:

- **the handle**—shape (pulled, pushed, lifted, lever, vertical, horizontal, other—can change the ease and convenience of opening the door) and position (the adjustment to the anthropometric dimensions of the user must be checked);

- **the shape and dimensions of the key**—mechanical key, key with remote control, card (automatic locking and opening of the door makes it easier to operate);

- **the boot**—especially for assisting the process of boarding a disabled person and loading the trolley by an accompanying person (flat boot sill, separately opened trunk lid and glass, handles and containers for fastening transported goods, automatic folding of the seats using a lever, flat surface after folding the seats, simple folding of the back seats); the boot lid opens downwards to form one surface with the loading surface, boot hoist;
the floor—flat floor with/without a tunnel, floor with/without door sills (certain car models have no door sills inside the vehicle making it easy to get in and out of the car);

seat adjustment—the best is multi-zone electric adjustment with settings memory, lumbar support adjustment, heating and ventilation, massage.

If a vehicle does not meet the needs of seniors, it is necessary to use optional devices, such as: special accelerator, brake or clutch pedal extenders if the longitudinal adjustment range of the seat is too small; additional seat cushions and backrests; sun visor extension shields to increase effective shading area; steering wheel covers to increase its width; safety belt extensions to fasten the belt in a comfortable place; a panoramic rear-view mirror; additional grab bars to assist getting in and out of the vehicle and graspable handles; enlarged handbrake grips, as well as extended turn-signal levers and wipers, etc.

METHODICAL FOUNDATIONS OF APPLICATION OF CHECKLISTS IN ERGONOMIC TESTS

Checklists in ergonomic tests serve for systematising, analysis and assessment of different work or work performance factors [3], [5]. Checklists in general mean allowing for diagnosis, i.e. recognition of the condition on the basis of the observed symptoms. An ergonomic diagnosis is a specific source of the data completing the information about a person and a technical facility in the context of an anthropotechnical or sociotechnical system [6]. A functional and spatial selection of a proper solution may be based on tests of the existing technical measures with the participative support of the activities by users along with specialist-advisors. Checklists are considered as appropriate for some stages of an ergonomic analysis (as opposed to a synthesis), and they are even more appropriate to help the operators (not the ergonomists) in the procedural method [7]. They can also be applied by persons who, while purchasing different products, make use of knowledge concerning not only the basic performance criteria, but also overarching ones related, for example, to the possibility of safe use. It often requires support by a team of branch experts [6].

In the ergonomic designing, the problem is the possibility to use checklists only after the designing process due to the necessity of referring them to a physical facility. It hinders the introduction of changes in the product [8], [9]. The subject of the work, however, is the issue of the choice of a technical measure (e.g. a purchase of a passenger car [10]) carried out after the completed design process. In this area of activity, there is a need to choose a product among all the existing solutions on the basis of the adopted assessment criteria. These criteria, for the purposes of an ergonomic analysis, are written in the form of checklists. A general, superficial, sometimes unclear or only qualitative (instead of quantitative) nature of well-known ergonomic checklists (e.g. Dortmund list, CET II [11-13] or Murrella [14]) has led to such a general and rather vague result of the choice of a technical measure and numerous problems with interpretation of the results of the applied list [8], [15]. On the basis thereof, it is impossible or difficult to, for example, estimate the degree of harm regarding the potential ergonomic risk factors occurring [16]. Moreover, by focusing on simple questions, often requiring only “yes or no” answers, some checklists may reduce human factors to a simple incentive-responsive system instead of encouraging conceptual thinking [7]. In more recent lists, for example in the Pacholski list [17], the
answers are summarized by a computer system. Attention is also paid to an important aspect of the motivation of the person interested in the assessment, and the results of such analyses are used for further assessment carried out by experts [18]. Ergonomic checklists for assessment of working conditions should also take into consideration factors in the form of: arduousness of working conditions and should take into account subjective assessments of working conditions. However, it is beneficial to make the person filling out the checklist aware of why each issue addressed in asked questions must be resolved. In this way, we eliminate errors related to the system functioning or its assessment. A proper action strategy is also created in this manner [7]. Newly-developed lists reduce imperfections of those previously applied.

A CHECKLIST FACILITATING CAR SELECTION

Potential drivers can assess individually or with the help of a team of advisers – experts who can advise whether technical solutions used in a car are adapted to their needs and the involutory changes that occur in them. Evaluating the state of car adaptation based on a range of symptoms provides data regarding the tested object which, in this case, is the ‘driver-vehicle’ anthropotechnical system. A checklist is a typical ergonomic assessment tool that can help in this activity. Answering the questions contained in it increases the certainty of buying the right vehicle. It is often difficult to find the information necessary for a fully rational purchase of a car. A checklist is based on the expectations of people irrespective of age and fitness, such as reliability, acceleration, comfort, price, car operating cost, etc. It should also contain a number of questions resulting from the specificity of seniors’ expectations and behaviour. There is information available in the literature (popular automotive magazines, the internet) which can expand the knowledge of a potential driver about possible alternative solutions. These include publicly available information about cars, including all dimensions of the body and interior and the type of functional and constructional solutions used. Costs are an important point in a checklist. In addition to the cost of purchasing a car, attention should be paid to additional costs, such as those connected with the purchase of accessories making it easier to get in the car, driving and operating it, as well as general costs of operation, service and insurance. They can often be the ultimate reason for choosing a vehicle.

Drivers can personally assess whether a vehicle meets their operational needs and make an in-depth analysis of the car’s individual features through the prism of questions formulated in a checklist. After completing questionnaires about several tested vehicles, they can compare the data obtained and refer them to general guidelines. The basic operational parameters of a car include: the geometry and dimensions of the door opening (height: e.g. from 870 mm to 1.125 mm, width: from 820 mm to 1.200 mm); door opening angle; sill dimensions (e.g. the height from the roadway to the car floor: from 320 mm to 530 mm, the height from the car floor: from 5 mm to 140 mm, width); the height of the upper edge of the door opening; cabin width; the geometry and adjustment of the driver’s seat; steering wheel; mirrors and sun visors.

When choosing a car, one should take account of the variability of vehicle construction with respect to the previously mentioned phases of its use, such as getting in and out of the car, driving and performing other operational activities.

Before buying a car, one should answer the following questions in the checklist about typical vehicle operation activities: (1) **Door opening**—Are the remote-control
buttons easy to use (size, arrangement)? Does the remote control have the right size? Are the handles comfortable (size, shape, position)? Are they easy to grasp? Are the handles at the correct height? Are the doors susceptible to changing the opening angle under the influence of wind or other factors? Does the door opening limiter ensure proper adjustment of the door opening angle? Do they open wide enough? Can the door handles be reached by hand if they are open very wide? Does opening the door require excessive force?, (2) **Body rotation and rear entry**—Are there comfortable and stable grab bars making it easier to get in? The seat is not too far away from the door sill? Is the seat too high or too low? Does the upper edge of the door opening limit the possibility of getting in (risk of hits)? Is it possible to hit elbows or hips against the door posts due to small spacing? Is the shape of the door edge reinforcements convenient to grip? Are there any sharp edges that can cause pain? Can the shape of the side seat supports make it difficult to get in? Is the seat hard enough (soft edges can be dangerous when changing seats)? Are the hand support areas rigid and durable? Is the seat flat enough to get in (and when changing seats)? Is the seat upholstery correct (type, durability, roughness, sliding on the seat)?, (3) **The body rotates 90° when sitting on the seat**—Is the process simple and safe (maintaining body stability), or does it require excessive force? Is it easy to move the legs over the car sill (is the car sill low and narrow)? Does the rotation process hinder the position of the steering wheel or other dashboard components? Does the door provide a stable hand support? Does it open/close when inserting the feet? Are there any handles in the car cabin, e.g. in the roof on the passenger's side and on the driver’s side for easy positioning? Is the car seat sufficiently firm and stable while sitting?, (4) **Possible supportive technical devices in the car cabin and the boot**—e.g. a walking stick, a crutch or a walking frame placed by a disabled person or an accompanying person. Is there a safe place for these devices in the car? Must other people be asked for help when placing these devices in the car? Is there enough space in the boot for transporting additional assistive devices? Can the boot floor be drawn out like a drawer? Is it possible to fold the seats from the side of the boot? Does opening and closing the boot lid require much force?, (5) **Closing the door**—Is the handle within reach when the door is open? Is the closing force required within the driver’s ability?, (6) **Preparation for driving**—Can the seat belt be easily reached? Does pulling the belt require a lot of force? Is it easy to locate the seat belt buckle and insert the belt?, (7) **Driving**—Is the line of sight higher than approx. 8 cm above the steering wheel? Are there at least 25 cm between the steering wheel and the upper torso? Can the feet easily reach the brake, clutch and accelerator pedals? Can the hands easily reach the handbrake and other control devices (radio, ventilation, emergency lights)?, (8) When choosing a car with the help of the checklist, one can also ask supplementary questions about all points: Are the handles and support areas adequately strong and located in the right places?; Are there any dangerous sharp edges and hard surface areas that may create the risk of hits?; Is there a risk of abrasions, cuts and dislocations?; Do the support areas ensure the correct transfer of loads (stability of support), etc.?

The use of a checklist makes it possible to formalise vehicle operation assessment when buying a car. This reduces the uncertainty of making a wrong purchase decision.
Among the most important issues for senior drivers before buying a car are the questions of whether they can still drive a car and when to stop driving. However, there is no clear indication that people at a certain age should not drive any longer. At the same time, it can be said that modern vehicles, thanks to advanced construction solutions, largely facilitate, and even allow (autonomous cars), senior drivers to keep their old lifestyles. Every form of activity contributes to maintaining good physical and mental health over a long period of time, resulting in positive interpersonal relationships. Regular health check-ups and developing individual skills help maintain driving abilities. The inevitable involutionary process in those who want to ‘live a full life’ despite old age, forces them to replace their cars with vehicles that are better suited to the needs of the elderly or to adapt the existing cars (by applying a number of retrofits to specific dysfunctions). This increases the possibility of using their vehicle. In many cases, it is enough to use simple vehicle adaptations that do not significantly increase the cost of the car. It is not possible to clearly indicate which vehicle is the most advantageous for a senior driver. This is often a matter of individual user preference. A checklist makes it possible to verify a large number of variables characterising a car, making it easier to decide on the choice of vehicle, or it possibly confirms that the previous choice was correct.

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