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What is This?
USABILITY OF THE GRAPHIC INFORMATION, NAVIGATION SYSTEMS AND CARS FOR SENIORS AND DISABLED

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Authors conducted survey and conversion of information on space and aviation ergonomics to the car, computer, navigation and communication systems design. These achievements and methods are particularly important for the fast growing needs and market of special solutions for elderly and disabled drivers.

New principles ("laws") of automotive ergonomics and methods of individual adaptation of human-computer dialogue were developed based on theory of ergodynamics (Venda and Venda, 1995). They were applied to usability analysis of navigation systems for vision and hearing impaired and other drivers who need a customized car and driver-computer dialogue. We studied experimentally perception of navigation maps by drivers with different vision disabilities (anomalies).

45 people of the ages of 20-30 and 60 subjects of the ages 55-75 with different types of astigmatism participated in the experiment. We displayed information by projecting slides on a screen, with a computer display, with a TV display, LCD panel and with various point lighting matrices. We changed the shape of the symbols, the distance of perception, vision angle, general lighting on the work station, brightness and contrast of the symbols on the screens.

INTRODUCTION

This study was initiated by R. Trybus, N. Venda and V. Venda on the contract with Honda of Americas R&D. The main goal was to survey, convert and use information on space and aviation ergonomics for car design. We summarized a huge body of achievements in the space, aviation and military ergonomics and psychology directly or potentially applicable to the car, on board computer and navigation and communication systems design. These achievements and methods might be particularly important for the fast growing needs and market of special car solutions for elderly drivers. To expand these and other our studies in human factors, work safety and usability, we have organized an International Institute (Network) of Ergonomics and Work Safety. We are interesting in cooperation with international telecommunication, car and navigation systems makers.

SEARCH FOR AND CONVERSION OF ERGONOMIC SOLUTIONS

1. Aviation and space ergonomics in application to the car navigation systems.

The survey is directly applicable to the following tasks:
1.1. Ergonomic Assessment and Design of GPS Driven Maps.
1.2. Individual Adaptation of Driver’s Task and Navigation Map.
1.3. Interactive route guidance systems (RGS) for GPS.
1.4. Route Guidance Destination Entry Methods.
1.5. Ergonomic assessment and design of displays for the advanced traveler information system (ATIS).
1.6. Use of infrared based night vision systems in cars.
1.7. Methods of driver’s voice analysis to predict stress, fatigue, and prevent emergency situations.
1.8. Methods of recognition of driver’s (human operator’s) psycho-physiological state.
1.10. Design of individually adaptive visual and voice driver-computer dialogue.
We have developed an international computer database on studies in space, aviation and military ergonomics applicable to the car design and other ergonomic projects.

2. Car and Navigation System for Senior and Disabled Drivers.

2.1. Objectives of our International Program: To find out: What do seniors dream to have in their cars? What psychological innovations and ergonomic design of cars we may offer seniors?
2.2. Analysis of psychological, physiological and ergonomic characteristics of elderly driver.
2.3. Ergonomic design: Functional data for the older population
2.4. Sensory changes with age
2.5. Acuity, contrast and color
2.6. Visual field
2.7. Cognitive changes in aging
2.8. Questionnaire on a senior dream car
2.9. Concept of the Senior Dream Car.
For the usability study we developed a questionnaire and questioned 890 senior drivers of the age of 65-80. The questionnaire consisted of 112 questions. So far only preliminary processing was made. The questionnaire is used by our colleagues at InterInErgo in several countries.

SPECIFIC USABILITY FUNCTIONS OF A SENIOR DREAM CAR

Here are examples of usability features of the high priority that were found important to attract elderly customers:
1. Easier to get in and out of the car.
2. To have adequate presentation of safety, navigation and driving information. To communicate automatically in emergency.
4. To have pleasant audiovisual communication.
5. To have a car more visible when it stalled in darkness.
6. Easy to operate controls.
7. Navigation maps adapted to individual perception.

Some other functions:
1. The senior dream car may play role of a friend, personal counselor-coach and nurse in order to:
   1.1. Advise senior on ability his/her to drive safely today. For this purpose a questionnaire presented on a touch screen, or through interactive voice recognition system, or in a combined visual-audio system, may ask senior questions and analyze her/his answers about: 1.1.1. Health; 1.1.2. Mood; 1.1.3. Stress. 1.1.4. To compensate psychological consequences of the post-traumatic stress to assist elderly driver in correction of behavior, information and psychological support of drivers and who had severe car accident.
1.2. Test the senior sensory systems:
   1.2.1. Vision: acuteness
   1.2.2. Vision: color sensitivity
   1.2.3. Vision: astigmatism
   1.2.4. Hearing: check of sensitivity
   1.2.5. Hearing: check of loss in comparison with previous time.
1.3. Test the senior reaction time and ability to process information and predict dynamics of the road situation
1.4. Test the senior motion coordination
1.5. Test the senior mental abilities
1.6. Test the senior memory, attention concentration and distribution
1.7. Measure the senior:
   1.7.1. Blood pressure
   1.7.2. Tremor
   1.7.3. Strength of hands and feet
1.8. Record the senior report how she/he was driving and analyze her/his previous errors, dangerous situations and accidents
1.9. Advise on safety actions, for example: Have a rest, or Do not drive today, or Call your doctor, etc.

Elderly (as well as any other) customer must have a choice what type of communication is desirable, helpful, and not annoying. For that we will create a software for questionnaires offered to the elderly customers at every dealer outlet
and for all flexible characteristics of the senior
dream car.
1.10. Record a self-report on today driving (after
return home)
2. Senior dream car may help as a secretary
3. Senior dream car must be a navigator-advisor:
3.1. Help to return home from any point by giving
detail advice on every turn;
3.2. Advise how to reach a place needed, what is a
better route and how to ride it (by giving detail
advice on every turn);
4. Automatic SOS-communication:
5. Driver (and passenger) seat must be much more
individually adjustable and dynamic than existing
seats.
5.1. Seat must turn left and move out when senior
is getting out; seat must turn left, go out, then turn
right and go in when senior is getting in; or
5.2. Ceiling must be high enough or partly open to
allow easier in and out; car roof might be partly
open when senior is getting in and out (with
special handle blocking this automatic connection
in rain and other circumstances);
5.3. Driver (and passenger) seat shape must be
individually adjustable much better than luxury
cars provide now.
5.4. Dynamically inflating, deflating and vibrating
on various individual programs seat cushion and
back support may help to massage muscles and
improve blood circulation.
It is desirable to make seats wider and more flat,
and as a rule to avoid bucket seats for seniors.

NAVIGATION SYSTEMS FOR VISION AND
HEARING IMPAIRED DRIVERS.

We studied experimentally perception of
navigation maps by drivers with different vision
disabilities (anomalies).
45 people of the ages of 20-30 and 60 subjects of
the ages 55-75 with different types of astigmatism
participated in the experiment. We displayed
information by projecting slides on a screen, with a
computer display, with a TV display, LCD panel
and with various point lighting matrices. We
changed the shape of the symbols, the distance of
perception, vision angle, general lighting on the
work station, brightness and contrast of the
symbols on the screens.
1. Reliability of map perception depends on type of
vision anomaly.
2. Astigmatism complicated with myopia is a wide­
spread eye anomaly.
3. Many people are not aware of their astigmatism.
4. Three groups of subjects with different types of
astigmatism participated in the experiments.
5. People with direct astigmatism had difficulty
perceiving horizontal lines on map, they often lost
these information elements.
6. People with reversal astigmatism had difficulty
perceiving vertical elements, they often cannot see
vertical lines on map.
7. People with oblique astigmatism had troubles
perceiving incline lines with different slope angles.
8. All three groups and some specific anomalies in
a depth and distance perception, strongly
depending on lighting types and levels, vision
angles, subject head positions etc.
9. The subjects' drawings of the maps showed
what elements they are missing.
10. Changing the subject's head position or that of
the map often changed the subject's perception of
different elements on the map.
11. Additional head motions to change the position
and perception lead to higher muscle strain and
fatigue.
12. The visual keenness of astigmatic people
decreased much faster than for those with normal
vision when the lighting level dropped.
13. Perception of navigation map by the astigmatic
person takes much more time than by person with
a normal vision and leads faster to fatigue.
14. The size of the symbol perceived depended on
the person's type of astigmatism. For example,
subjects with direct astigmatism usually saw the
symbols as much higher than the normal subjects
saw. People with reverse astigmatism saw the
symbols as lower than in reality, but much wider.
15. There are some models for the astigmatic
perception distortion that might allow to create
principles to design and adapt the navigation maps
to the drivers with vision disabilities. We found
that for 80% of subjects with direct astigmatism,
the main elements on map should have angles
between 80-130 degrees.
The subjects with reverse astigmatism perceive
elements best between the angles of 0-15 degrees.
For subjects with oblique astigmatism, the angles
in the intervals 40-50 degrees and 100-110 degrees were the best. These our preliminary studies led us to the conclusion that individual adaptation of navigation maps and other information to the drivers with astigmatism and other visual deficiencies will decrease their visual and muscle strain, fatigue and errors in the navigation map perception.

**ERGODYNAMICS PRINCIPLES OF CAR USABILITY**

The First Principle of car usability: A car criterion (safety, comfort, driving satisfaction, or attraction), \( Q_c \), for a driver is a bell-shaped function of any factor \( F_j \) of mutual adaptation between driver and the car, \( Q_c(F_j) \).

The Second Principle of car usability: Driver may use different strategies in perception and processing information, making decisions, in physical interaction with car. For each strategy the car ergonomic quality criterion, \( Q_c \), will be presented with a particular bell shaped function \( Q_c(F_j) \).

The Third Principle of car usability: Transformations between two different driving strategies \( Q_1 \) and \( Q_2 \) go through a state common and equal for both strategies presented as an intersect point of two bell-shaped characteristic curves \( Q_1(F_j) \) and \( Q_2(F_j) \). One of many corollaries of the third law is: when emergency occurs and driver transforms his/her normal strategy into emergency strategy, first efficiency and reliability of driver's actions go not up, but down until the strategies are transformed. Car design and driver training must be directed specifically to help drivers to expedite the transformations. This may be a key point in increase of traffic safety.

**CONCLUSION**

1. Conversion of information on space and aviation ergonomics helps to find quick effective solutions particularly for elderly and disabled users.
2. Principles ("laws") of ergodynamics are applicable to usability analysis of navigation systems and driver-computer dialogue.
3. Usability of navigation maps for drivers with different vision disabilities (anomalies) require special experimental methods and solutions.
4. Individual adaptation of navigation maps and other information to the drivers with astigmatism and other visual deficiencies decrease their visual strain, fatigue and errors in the navigation map perception.

**REFERENCES**


