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Avoiding driver drowsiness

Measuring the level of fatigue during driving is an important scientific and technological challenge, and is also a primary objective in improving road safety. IBV participated in an extensive research project, analysing the behaviour of a group of users in a driving simulator installed in the user-oriented lab. In these experiments, the participants drove the simulator in drowsy conditions, their state during the sessions was assessed, and we tested the reliability of assessing their drowsiness level by means of driving performance variables (lateral and speed control), as well as by physiological signals that could be the basis for new non-invasive technologies to measure driver fatigue.

INTRODUCTION

Drowsiness at the wheel is one of the main road safety problems and is the leading cause of more than 20% of serious and fatal road accidents. For this reason, manufacturers of automotive parts, such as FICOSA International, have prioritised the development of drowsiness detection systems and algorithms that will render it possible to predict it before the risk of an accident is imminent.

The driver’s physiological signals, as well as visual, cardiac and brain activity are particularly useful for obtaining detailed information on the body’s response during the sleep cycle. This information goes further than the usual systems, which simply detect whether driving is affected by sleep (for example lapsing out of the lane, abrupt steering wheel manoeuvres, irregular changes of speed, etc.), and are potentially very useful indicators for pre-empting the situation of imminent risk.

More particularly, it has been demonstrated that the “percentage of eye closure” (PERCLOS), HRV (heart rate variability) and the “alpha and theta” wave patterns in the electroencephalogram (EEG) are variables directly related to fatigue and loss of attention. However, most of the studies of these variables have been performed in clinical contexts, during somnography tests with patients lying down and doing little activity. Performing and analysing these measurements in a driving context heralds an important technological and scientific challenge for different reasons: the need to use minimally invasive measuring instruments so as not to interfere in the driver’s activity, as well as the difficulty of submitting the driver to conditions of fatigue to be able to validate the detection techniques. Moreover, producing these situations in a real driving setting would entail an unacceptable risk, hence experiments must be limited to tests in a controlled context without any risk of accidents.

To tackle this challenge, FICOSA, the IBV and the University of Alcalá de Henares have collaborated in a research project on drowsiness, using the automotive and people-oriented design laboratories of the Instituto de Biomecánica as a simulation environment. This project involved experiments with users and instruments in a driving simulator, and was geared towards fulfilling three objectives:

1. Obtaining a database of physiological signals synchronised with driving parameters and the drivers’ body movements, both when wide awake and drowsy, which may be used to study the changes related to a lack of attention and fatigue.

2. Defining a control variable based on PERCLOS and EEG to classify the different phases of the onset of drowsiness during driving.
3. Finding patterns in the other variables that make it possible to distinguish between the phases defined, as advanced base methods for the detection and prevention of drowsiness.

**Methodology used**

Twenty (20) drivers aged between 25 and 45 participated in the experiments. Half of them did the experiment after sleeping normally the night before and the other half did so after being awake for more than 24 hours. There were 5 men and 5 women in each group, who were selected taking into account that they had not consumed stimulants and were not prone to simulator dizziness syndrome.

Lighting in the laboratory was minimised, the temperature was between 24 °C and 26 °C and a nighttime on-the-road sound environment was created to induce fatigue. The driving simulator was installed in a platform with a clinical polysomnograph that recorded physiological signals and an infrared camera system of the University of Alcalá which measured the PERCLOS level at the same time (Figure 1). Moreover, pressure sensors continuously recorded pressure maps on the driver’s seat and backrest. The laboratory and instruments were controlled by a network of seven computers managed by two investigators. All computing equipment and investigators were hidden from the user to avoid distraction.

Before each measuring session the users drove for a period of between 15 and 30 minutes to become familiar with the simulator. The test consisted of 1 hour and 45 minutes of monotonous driving along a motorway with hardly any traffic, in nighttime conditions conducive to fatigue, but with an economic incentive if they completed the test without showing sleep symptoms. After this phase, a totally dark and silent setting was created and the user was told to remain seated with their eyes closed to provide a base measurement of physiological activity in a context of total drowsiness without driving.

The PERCLOS and EEG values were used together with the driving signals to define a control signal for the driver’s status, which was classified for each instant in one of the following phases: “Phase 0” (normal attention), “Phase I” (incipient fatigue and moderate loss of attention) or “Phase II” (imminent risk of falling asleep, with major deterioration in vehicle control). The deepest phases of drowsiness (total lack of attention or consciousness) that are used in sleep studies were not considered in this experiment, since they are of no interest for a system for the early detection of drowsiness.

The analysis of the measurements demonstrated that despite the economic incentive of remaining awake, the context created got 80% of the users to go through fatigue Phase I, and 20% reached Phase II at least once when the measurements were taken (reaching 30% in the sleep-deprived group). These periods of fatigue or sleep occurred successively with durations of around a minute and a half, which once added up accounted for more than 10% of measuring time.

**Results**

The analysis of the measurements demonstrated that despite the economic incentive of remaining awake, the context created got 80% of the users to go through fatigue Phase I, and 20% reached Phase II at least once when the measurements were taken (reaching 30% in the sleep-deprived group). These periods of fatigue or sleep occurred successively with durations of around a minute and a half, which once added up accounted for more than 10% of measuring time.

**Table 1**

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>PHASE 0 (ATTENTION)</th>
<th>PHASE I (FATIGUE)</th>
<th>PHASE II (DROWSINESS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRIVING</td>
<td>Attentive, with good control</td>
<td>Slow reactions and mistakes</td>
<td>Loss of attention, slips out of the lane</td>
</tr>
<tr>
<td>EEG</td>
<td>Proportion of theta waves less than 1.9, with regular alpha wave patterns</td>
<td>Proportion of theta waves between 1.9 and 8.2, with regular alpha wave patterns</td>
<td>Proportion of theta waves more than 8.2, with regular alpha wave patterns</td>
</tr>
<tr>
<td>PERCLOS</td>
<td>Less than 24%, fast blinking</td>
<td>Between 24% and 45%, frequent blinking</td>
<td>Above 45%, slow and long blinking</td>
</tr>
</tbody>
</table>
incipient fatigue, as many fatigue symptoms (47% of cases) go unnoticed until the driver enters “Phase II”.

Fortunately, it was discovered that other physiological indicators, such as heart rate variability (HRV) and breathing, can be effectively related to the general condition of the user and the phase of each instant. More specifically, HRV fell significantly in the users of the private sleep group, and abdominal movement due to breathing was broader during phases I and II.

The non-invasive measuring of these variables through devices integrated in parts of the vehicle (seat, steering wheel, safety belt...) is much more feasible than that of the EEG which was used as a control signal, hence this result opens up the way for viable and efficacious improvements in drowsiness detectors.

On exploring non-invasive routes for measuring these physiological variables, we found particularly that the dynamic behaviour of the mean pressure in seat and backrest correlate to the breathing signal, although this correlation is observed in sections and depends on the person (it was observed...
in 50% of users). Figure 3 shows an example of breathing and pressure signals in seat and backrest, where this correlation is clearly appreciated.

Conclusions

The experiments performed in this project rendered it possible to study how drivers react in conditions of drowsiness through induced fatigue but they try to stay awake. The alternating and relatively short periods of incipient fatigue and sleep that were observed were a good approach to the typical episodes of “microsleep” that occur behind the wheel and which are the cause of many fatigue-related road accidents.

The control signal, comprised of a combination of brain and visual activity and behaviour observed at the steering wheel, was compared, on the one hand, to the driving variables considered by many drowsiness detection devices under development and, moreover, to physiological variables that could be easier to measure.

The first comparison revealed that detectors based on driving signals alone make it possible to correctly recognise the moment when the driver is wakeful as well as episodes of drowsiness with a considerable risk of accident. Therefore, they may be suitable for systems that “wake up” the driver in such an eventuality, but need to be complemented by other signals to efficaciously detect incipient periods of fatigue and pre-empt the risk of accidents.

One of the options currently addressed in many drowsiness detectors under development, is the PERCLOS measurement, which was used in the control signal for analysis, with a precision of greater than 95%. Moreover, heart rate and breathing were shown to be related to changes in the driver’s status and that there are good expectations for being able to measure these physiological variables with non-invasive means.

These results provide a promising base for the development of advanced drowsiness detectors developed through the combination of signals. Naturally, there are other important challenges that need to be addressed, such as the manufacturing of these sensors, their integration in the vehicle’s structure and validation outside the laboratory, all of them objectives on which the companies and centres involved continue to work.

Acknowledgements

We would like to thank FICOSA International S.A. and the University of Alcalá for their contribution to this project.
Driving Monitoring System implementable in any means of transport

Ambimetrics, in collaboration with the Instituto de Biomecánica (IBV), has developed a driving monitoring system adaptable to different means of transport. The objective of this project was to expand the instruments and systems capabilities of Ambimetrics through the construction of a mobile data logger (EMAD) to monitor driver behaviour in railway and road vehicles. This project enabled the company to develop a new product, based on GSM technology and motion sensors, with multiple capabilities, while also constituting an advance in the company’s tools and core knowledge. The device is intended to be used, in the short term, for scientific purposes, and will be used as the core for possible commercial applications, ranging from fleet management to customized services based on the use of vehicle or traffic, to be developed in a very near future.
monitoring of driving behaviour, besides the environmental conditions that may affect vehicle conservation and maintenance.

Development began with a prototype that featured non-integrated modules to perform the operating tests and validate measurement (Figure 1). This prototype was used to define a more compact design to be installed on board vehicles for different tests (EMAD v2011).

Table 1. Characteristics of the EMAD v2011.

<table>
<thead>
<tr>
<th>MEASURING CHARACTERISTICS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-axis accelerometer (±2 g) for measuring movement.</td>
</tr>
<tr>
<td>Three-axis accelerometer (±2 g) for measuring vibrations.</td>
</tr>
<tr>
<td>3-axis magnetometer for measuring the magnetic field.</td>
</tr>
<tr>
<td>Calculation of pitch, yaw and roll compensated in inclination (0 ÷ ±360°).</td>
</tr>
<tr>
<td>Broad range digital temperature sensor (-40 ÷ 123 °C).</td>
</tr>
<tr>
<td>Comprehensive range digital humidity sensor (0 ÷ 100 %RH).</td>
</tr>
<tr>
<td>Five 10-bit analogue inputs for external sensors.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RECORDING CHARACTERISTICS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD/SDHC memory card slot.</td>
</tr>
<tr>
<td>Data are recorded in independent daily files.</td>
</tr>
<tr>
<td>Record based on changes in (configurable) sensor values.</td>
</tr>
<tr>
<td>Real-time clock with a duration of up to 5 years.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONNECTION CHARACTERISTICS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB 2.0 connection port.</td>
</tr>
<tr>
<td>MSD/HID connection interface.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONFIGURATION CHARACTERISTICS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration values are saved if there is no power.</td>
</tr>
<tr>
<td>Configuration values of the measuring range in each one of the sensors.</td>
</tr>
<tr>
<td>Constant of the variation percentage for recording by each sensor.</td>
</tr>
<tr>
<td>Constant for noise filtering for recording by each sensor.</td>
</tr>
<tr>
<td>Adjustable reading time for each sensor.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DIMENSIONS AND POWER SUPPLY:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply: 12 Vdc, 150 mA (battery or external power).</td>
</tr>
<tr>
<td>Dimensions: 7 x 9 x 6 cm.</td>
</tr>
</tbody>
</table>

The EMAD v2011 can measure accelerations, vibrations, temperature and humidity, as well as the signal issued by any analogue sensor that is connected to its external inputs once they have been prepared. It is comprised of a 32-bit microcontroller, an SD card socket, a USB connector, a real-time
clock/calendar, 5 external analogue inputs and the internal sensors: 2 sensors for measuring accelerations in 3 axes, a magnetic field sensor (magnetometer) and a temperature and humidity sensor.

Moreover, the device’s database can be downloaded to an external storage device by USB or be transmitted it by GSM, and it also features software for configuration and monitoring.

**Development of the software**

The EMAD configuration application is an auxiliary tool that is used to configure and interact with the device through the USB 2.0 connection. This application makes it possible to modify the EMAD’s configuration, as well as to create, save and transfer other configurations to it. Besides configuring the EMAD devices, the application is used to configure the internal clock and view channel values numerically or graphically.

The main screen (Figure 3) is used to access “Channel configuration”, the “Configuration manager” and “Dynamic graphics”, where a new screen is opened and can generate real-time graphics of the data received, displaying or concealing the required channels.

The measuring values are distributed by means of channels, permitting the independent configuration of its settings. The user can modify both channel and overall settings (Figure 4).

Summarising, the EMAD can be configured in different modes for recording data:

- Recording by change: the channels are recorded if there has been a change in their reading, according to the change constant and noise constant parameter configuration.
- Recording by reading: the channels are recorded whenever a reading is taken; the reading period is configurable.
- Recording by channels: in this recording mode every line recorded will contain the channels recorded separately.
- Constant recording: All the channels will be recorded at a constant reading time.

Figure 5 shows the potential display of the EMADv2011 application where the data of the additional GPS module and the parameters recorded during driving are integrated. This application allows the user to select two display formats: view in Google Maps® of the route travelled, and the graphic view, which permits interaction with the data recorded (both positioning and acceleration and vibrations), selecting the
parameters to be viewed and doing zooms in the areas of interest. The main screen is divided into 4 zones:

- Main menu, which makes it possible to select view, import data, select the parameters to be viewed and obtain statistics.
- Graphic of the route: Located top left, it displays the route taken during data capture.
- Parameter graphic: Located at the bottom, it displays the parameters recorded by the EMAD during the route (accelerations and vibrations in the 3 axes). This graphic is interactive and zooms can be made for better display.
- Speed or detail graphic. Located top right, it displays, depending on the button selected, speeds during the route or a zoom of the area selected by the cursor in the parameter graphic.

This viewing format makes it possible to quickly identify and analyse areas where events such as abrupt manoeuvres have taken place, and characterise the type of driving.

**Future development (EMAD v2012)**

The new version of the device (EMADv2012) will extend its functionalities and facilities, incorporating GPRS/GSM communication, the GPS chip, data encryption, increase in sampling speed and storage capacity. This zoom will increase versatility and will allow it to operate autonomously for longer and also monitor device incidents in real time.

**Applications**

EMAD has been designed for scientific purposes, and at the same time acts as a point of departure for possible commercial applications to be developed in the short term (operation support systems, fleet management) and in the medium-term (personalised services based on the use of the vehicle, traffic control, etc.).

The EMAD is currently being used by the IBV in studies to evaluate driver response in real vehicles; for example, observing how the design of the controls or the information systems affects drivers while handling the vehicle.

The monitoring of driving quality is an application with great interest for R&D in the transport industry. In that sense, the EMAD makes it possible to monitor, with a high level of detail, vehicle driving, providing information that can help to improve new services emerging, such as “Pay as you drive”, where the vehicle or insured driver is credited or charged depending on distances travelled, consumption, intensity of use, driving style, as well as to keep the vehicle in good condition and improve its maintenance.

The flexibility and customised configuration of the EMAD and the way it uses the results will permit a broad range of possibilities ranging from its use in measuring driving quality in public passenger transport (on-board driving assistant) or as a complement in burgeoning services such as car sharing.

**Acknowledgements**

Project funded by the IMPIVA through the Technological Research and Development Program 2010-2011. Co-funded by the ERDF Funds, within the ERDF operating programme of the Autonomous Community of Valencia 2007-2013.
El proyecto SAUDE ha tenido como objetivo el desarrollo de nueva indumentaria de protección (peto, chaqueta, botas y guantes) que mejore las condiciones de trabajo y de salud del marisqueo a pie. En el proyecto, financiado por la Consellería de Pesca e Asuntos Marítimos de la Xunta de Galicia y coordinado por CETMAR (Centro Tecnológico del Mar), han participado AGAMAR (Asociación Gallega de Mariscadoras) como usuarios finales de los desarrollos, LEITAT como desarrolladores de los prototipos e ISSGA (Instituto Gallego de Seguridad y Salud Laboral) en el asesoramiento médico para la prevención de riesgos laborales. El IBV ha participado en la incorporación del conocimiento y las metodologías para definir las necesidades de las mariscadoras y sus características antropométricas como base para el desarrollo de la nueva indumentaria, así como las metodologías de evaluación de riesgos ergonómicos de un puesto de trabajo tan especial como es el del marisqueo a pie.

**New protective garment for the “shellfish gatherer on foot” in Galicia**

The main objective of the SAUDE project was to develop new protective clothing (dungaree, jacket, boots and gloves) to improve the health and working conditions of the seafood harvesters.

**INTRODUCTION**

Shellfish harvesting is defined as a “specific fishing modality consisting of the extractive activity of gathering shellfish”. This activity is of great importance in Galicia and provides employment for more than 4,600 people, 4,100 of them women, in this Autonomous Community. "On foot" shellfish harvesting has evolved a great deal in terms of the use of different work tools. However, clothing has barely evolved, hence both the garments and footwear currently used are not adapted to the activities carried out, causing discomfort and even lesions due to a lack of mechanical and thermal protection.

The development of new clothing is intended to avoid or reduce the health risks for people engaged in on foot shellfish harvesting, be they musculoskeletal (back pain, tendinitis, bursitis, osteoporosis...) due to ergonomic problems, physical risks (jags, friction, bruising, cuts...) and risks associated with thermohygrometric conditions (high humidity, heat loss).

The project, funded by the Department of Fishing and Marine Affairs of the Government of Galicia and coordinated by CETMAR (Technological Centre of the Sea), included the participation of AGAMAR partners (Galician Association of shellfish harvesters) as end users of the developments, LEITAT as developers of the prototypes and ISSGA (Galician Institute of Occupational Safety and Health) in the medical assessment for the prevention of occupational risks. The role of the Instituto de Biomecánica (IBV) was to include the shellfish harvesters in the new clothing development process by means of the application of user-oriented design techniques, engaging the workers in the manufacture of initial specifications and the validation of the prototypes. In addition, the IBV worked on the adaptation of the prototypes to the specific anthropometry of this group of workers.

The project was funded by the “Xunta de Galicia” and coordinated by “CETMAR” (Technological Centre of the Sea). AGAMAR (Galician Association of shellfish harvesters) participated as end users, LEITAT (Textile technological centre) as prototypes developers and ISSGA (Galician Institute of Occupational Safety and Health) provided medical advice for the prevention of occupational hazards. IBV was involved in the incorporation of knowledge and methodologies to define the needs of seafood harvesters and their anthropometric characteristics as a basis for the development of new clothing, as well as methodologies for assessing the ergonomic hazards in such a special job.
Projects development

The project was implemented in four phases. In the first phase, different studies were performed, with the participation of the shellfish harvesters, whose objective was to detect problems and needs related to current clothing and tools, as well as a medical study and an analysis of the ergonomic risks of on-foot shellfish harvesting. In the second phase, ergonomic solutions were designed to tackle the problems found in the first phase and prototypes were developed according to the design specifications obtained. The third phase consisted of the transfer of the results to real-life situations and the validation of the prototypes developed. Finally, in the fourth phase, the results of the project were made known to the groups of shellfish harvesters. The work performed in each one of the project phases is detailed below:

PHASE 1. Courses for ascertaining problems associated with the clothing used in on-foot shellfish harvesting

First of all, the IBV performed an ergonomic analysis of the activities involved in on-foot shellfish harvesting to find out all the stances or actions that jeopardise the health of the shellfish harvesters and how the use of the current work tools benefit or compound these ailments. At the same time, the ISSGA performed a medical study of the group of shellfish harvesters. In this medical study, besides the information on the occupational diseases suffered by these workers, anthropometric information was collected on the women to subsequently serve as a design basis for the prototypes. Moreover, questionnaires were prepared to obtain information on the working conditions to which this group is exposed, paying special attention to clothing, protective, orthopaedic and/or corrective elements that the shellfish harvesters currently wear to work. These discussion groups revealed current problems and the needs of the shellfish harvesters with a view to developing new clothing and personal protection systems. This information is very important, since it is regarded as the basis on which to work to generate elements that are totally adapted to the users’ characteristics.

PHASE 2. Development of solutions and manufacture of prototypes

Once the information obtained from the discussion groups and the ergonomic analysis and medical study had been compiled and analysed, the requirements of the suit and protection elements to be developed were extracted. First of all a material search was performed - suited to the humidity conditions to which the shellfish harvesters are exposed. The textile materials currently used in this activity as a barrier between the marine environment and the user (to maintain watertightness and protect against the conditioning climatological factors of cold, wind, rain and prolonged solar incidence) are fabrics coated with thermoplastic polymers such as polyvinyl chloride (PVC), known as “water garments”; and synthetic rubbers based on polychloroprene, known as neoprenes and fishing waders. These garments work well as a watertight barrier, but they still have major limitations to be regarded as ideal clothing due to their limited transpirability and heat insulation. A trilaminate textile was proposed as an alternative, comprised of a membrane that prevents the passage of water, positioned like a sandwich between two textile structures, one of which, the outer one, provides mechanical protection and from the wind, with the other inner layer delivering insulation and comfort.

The LEITAT technological centre made sketches of the suit and its parts to guarantee watertightness (Figure 1). The sketch of the suit consists of a dungaree with straps to which a long-sleeved jacket can be fitted with a zip under the chest. In the area between the legs, buttocks and knees, the suit should be padded with a 3D fabric on the inside and a coating of abrasion-resistant fabric on the outside. Moreover, work was done to provide solutions for the problem of watertightness between trousers and boots. For this purpose, a system based on rigid rings with latex joins was devised to connect trousers and boots.

All the suit’s technical and design specifications were compiled and the prototypes (Figure 2) were made for evaluation with the users.

PHASE 3. Prototype evaluation

Tests were performed in the field with AGAMAR shellfish harvesters in several places in Galicia to validate the prototypes. The shellfish harvesters tested the prototypes in real working conditions for one day. Following the tests, an IBV-developed survey was carried out on the comfort perceived by the users.
Figure 2 shows pictures of the prototypes and figure 3 shows pictures of the shellfish harvesters trying out the prototypes.

**PHASE 4. Transfer of results and dissemination**

In this phase, a good practices guide for on-foot shellfish harvesting was developed. The guide consists of indications on postural behaviours to avoid discomfort and the appearance of lesions during the working day. Information was also included on the proper use and maintenance of the protective clothing developed during the project.

**CONCLUSIONS**

The project permitted the development of new clothing (dungaree, jacket, boots and gloves) adapted to the activities of on-foot shellfish harvesting. The new clothing developed enhances the thermal and watertightness properties of the current gear. Moreover, the design has been adapted to the specific anthropometric characteristics of the group of on-foot shellfish harvesters in Galicia.

The development of the clothing was closely related to the needs of shellfish harvesters, who personally evaluated the results of the project. Similarly, the good practices guide entailed a postural re-education in the jobs performed during shellfish harvesting.

The role of the Instituto de Biomecánica (IBV) in this project made it possible to include know-how and methodologies for gauging the opinion of the users and their current needs in terms of the clothing and tools used in their daily activity; as well as ergonomic risk assessment methodologies for a very special job, namely on-foot shellfish harvesting.

**ACKNOWLEDGEMENTS**

We would like to thank the Consellería de Pesca e Asuntos Marítimos de la Xunta de Galicia (Department of Fishing and Marine Affairs of the Government of Galicia) for funding the project, and CETMAR (Marine Technology Centre) for their support and coordination of all the work performed throughout it.

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Figure 3. Shellfish harvesters trying out the prototype developed in the SAUDE project.
**Innovation for Children**

*Design4Children* is the most ambitious European project carried out in relation to the design of products for children. It is coordinated by the Spanish Association of products for children (ASEPRI) and involves 12 organisations (R&D centres, associations and companies). With a budget of 1.5 M Euros, it covers 3 years. During the first year of the project, which has just ended, the IBV played a fundamental role generating knowledge, non-existent to date, to satisfy the comfort and safety needs of children aged 0 to 12 years. This knowledge includes the perception that parents have about children's products in the market and specific design criteria for children's products to ensure the health of children and comfort and usability for parents. In addition, the specifications of a set of innovative tools were defined, which will be developed over the coming two years, and will support designers, enabling them to introduce scientific knowledge regarding product comfort and usability into the design process, to ensure the comfort and welfare of children throughout the new product development process, advising parents what to buy and helping retailers to select the best products for sale.

**Introduction**

Traditionally the European children’s and child care fashion industry has remained competitive by reducing production costs through the roll-out of new product and process technologies. At this moment in time there is no doubt that this type of action no longer suffices to improve competitiveness.

*Design4Children* is an ambitious European project within the Seventh Framework Programme coordinated by ASEPRI, whose objective is to improve the competitiveness of the European children’s and child care fashion industry. To accomplish this, it focuses on people-oriented design, in this case children and parents, who are the main end users of this type of products.

The project features the participation of SMEs from three European countries (Portugal, Spain and Bulgaria), Associations from four European countries (Spain, Bulgaria, Italy and Finland) and "Children Fashion Europe (CFE)". The research part is coordinated by the Instituto de Biomecánica and a further two R&D Centres from Israel and the United Kingdom are also participating. (Figure 1). The project has a budget of around one and a half million Euros and has a three-year time frame. This article presents the project results after the first year.

While numerous research work has been conducted in adults to determine ergonomic and comfort criteria related to everyday-use products, less is known about children’s and parents’ needs in the case of children’s clothes and footwear and child care products. The needs of children differ significantly from adults, since they are going through a cognitive, physical (size and proportions) and physiological (particularly in terms of heat-regulation) development process. However, despite all these differences, the industry lacks suitable scientific knowledge.
Projects are developed to understand how to make sure that children’s products suitably cover their needs.

The Design4Children project aims to generate specific design criteria to improve the comfort of products for children. It thus seeks to furnish European SMEs with a set of innovative tools that will enable them to develop and offer high added-value products for children and parents. This objective will take the material form of three main results (Figure 2): (R1) “Design Supporter”, a computing application enabling designers to develop products that guarantee children’s comfort and welfare; (R2) “Virtual tester”, a virtual test bench that allows designers to evaluate the functional performance of their designs without the need to actually make them and (R3) “Purchase advisor”, a web-based platform that will give parents purchasing advice and help clients and retailers to select the products that best fit children’s needs.

**Methodology used**

The first year of the Design4Children project involved the knowledge generation phase, which consisted of four phases:

**Phase 1. Identification and analysis of current knowledge on children’s products**

At the beginning of the project, a bibliographic analysis of scientific journals and technology in the sector was performed, and panels were held with users, designer and paediatricians; distributors were interviewed and an ethnographic analysis performed. All the information obtained was analysed to detect any knowledge gaps that had to be covered (Figure 3).

**Phase 2. Generation of new knowledge on children’s products**

In this phase, new methodologies for the analysis of usability and heat-regulation in children were developed, and anthropometric measurements were obtained from the child population.
Both the companies that participate in the project and other companies associated with the collaborating Associations participated. More than 20 children aged between 0 and 12 years cooperated in the experiments (Figure 4).

Phase 3. Development of design criteria for children’s products

The work consisted of generating design criteria for children’s products that satisfy children’s needs.

Phase 4. Development of simulation models for testing children’s products

In the last phase of the work carried out during the first year of the project, simulation models of product-child interaction were designed that are capable of predicting the children’s level of satisfaction on using it.

RESULTS

The results generated in the tasks described were as following:

Children and parents’ needs

-- **The European childcare market was exhaustively characterised**, yielding an exhaustive compendium of *user needs* related to children’s products, including the perception of parents, designers and sellers of the products on the child market (needs, level of fulfilment of expectations, etc.).

Usability

-- **A total and global characterisation of the patterns of interaction between parents and products** such as children’s clothes and footwear and childcare items (pushchair, high chair, bouncy chairs/seats and baby carriers) was made, including behaviour, opinions and user preferences with each one of the products.

-- Finally, a *compendium of design recommendations was generated to guarantee the complete usability of children’s products* (advice for designers on ergonomics, parent and children comfort and safety) that can be used as a guide to create products that fully satisfy user needs.
> Anthropometrics

-- Complete anthropometric characterisation of the children, identifying more than 30 relevant international data bases, as well as the influence of movements and postures in child anthropometrics (Figure 5).

-- Construction of an international anthropometrics database for children aged 0 to 12 years, including more than forty different body sizes for different ethnic groups, and which considers different postures (standing, sitting, supine) and positions of the upper and lower limbs (e.g. flexion). These contents enable the database to serve three types of products: clothes, footwear and child care.

-- Set of adjustment criteria for children’s clothes and footwear (relationship between anthropometrics and perception of fit), including adaptation to the child’s movements.

Thermal comfort

-- Characterisation of the heat-regulating behaviour of the child population, as well as of the thermal characteristics of the materials used in child care products.

-- Design criteria to guarantee children’s thermal comfort, including an analysis of the thermal properties of the textiles and the criteria that should be followed to guarantee comfort in different environmental conditions and physical activity.

Simulation models

-- Development of an expert usability system for three products (clothes, footwear, child care) able to give designers advice to ensure that their products cover child and parent needs properly.

-- A clothes-fit simulator, based on the comparison between anthropometric data and new design sizes to predict the perception of fit.

-- A clothes thermal comfort simulator that can predict user temperature and perspiration.

Conclusions

One year into the Design4Children project, the IBV has successfully completed the main phase, consisting of generation knowledge on the following aspects:

-- Perception of users, designers, sellers and experts of children’s products (clothes, footwear and child care) currently on the market in aspects such as their adaptation to the anthropometrics (fit) and heat regulation (thermal comfort) of children and parents, as well as day-to-day usability (comfort, manageability, storage, folding, washing, maintenance, etc.).

-- Characteristics of European children aged 0 to 12 years, including their anthropometrics (full body), physiology (with regard to heat regulation system),
locomotor skills (most common movements and postures), etc., all taking into account the children’s evolution through growth and the variability and diversity which this involves.

- Needs of the children in their interaction with the products, considering aspects such as how far they fit their anthropometrics, adaptation to movements and postures, heat regulation and safety.

- Design criteria oriented towards the development of ergonomic and comfortable products, taking into account the restrictions imposed by the safety regulations.

Acknowledgements

We would like to thank the companies that gave us their time in the related panels and interviews for their participation: BEBEDUE, TUTTO PICCOLO, TUC TUC, BRAVOTEX, CLAIRE INFANTIL, MADU, BARCAROLA, MICONA, MAYORAL, BÜGILI, CANCIÓN DE CUNA, GOCCO, EL CORTE INGLES, CHARCO, TODOBEBE, BESÍSSIMO, INDYCO.

We would also like to thank the associations that participated in the project for their work in managing and liaising with the companies: ASEPRI, CFE, BAATPE, ECCIPA and MKL.

We also wish to thank the European Commission for its financial backing in the implementation of the project within the call of the “Research for SME associations” 7th Framework Programme.
Realizar un proceso de compra adecuado es clave para asegurar que un producto o servicio se ajusta a nuestras necesidades, capacidades y preferencias.

De lo contrario, nos podemos encontrar con productos y servicios que nos dificultan o incluso impiden su uso. Estos problemas se intensifican en las personas mayores ya que, generalmente, muchos de los productos y servicios no se ajustan a sus capacidades.

Por ello, se ha desarrollado una innovadora metodología que permite formar a los mayores en el proceso de compra, y que éstos, a su vez, sean capaces de transmitir los conocimientos a otros mayores. Así se favorece una rápida y eficiente transmisión de las claves en el proceso de compra.

Este proyecto, realizado en colaboración con la UDP, se enmarca en las campañas de formación, promoción y sensibilización alrededor del sello SIMPLIT.

**Older people: learning how to purchase**

Proper purchasing is a key process in ensuring that a product or service meets our needs, capabilities and preferences. Otherwise, we can find products and services that may hinder or even prevent their use. These problems are even more important in older persons, as many products and services do not meet their capabilities. For this reason, an innovative training methodology has been developed for educating older persons in the purchasing process and at the same time for enabling them to transfer the knowledge to other seniors. This promotes a fast and efficient transmission of the keys to the purchasing process.

This project, performed together with UDP, is framed under the training, promotion and awareness campaigns of the SIMPLIT seal.

**Older people: learning how to purchase**

Estela Suárez García1, José Laparra Hernández1, Cristina Fernández Palomo2, María Sancho Moliná1, Laura Pérez Morata1, Antonio Gómez González1, Clara Bollaín Pastor1, Amparo Guerrero Alonso1,3, Rakel Poveda Puente1

1 Instituto de Biomecánica de Valencia
2 Unión Democrática de Pensionistas y Jubilados de España
3 Universitat Politècnica de València

**INTRODUCTION**

Consumption is a process involving a series of stages intended to obtain a certain product from among several available on the market. This is something that all people do regularly, and we might say that consumption and shopping or buying are activities that are part of our lifestyle.

According to the "Purchasing and consumption habits of the older persons" (IBV, 2006) study, 26% of the sales of mass consumption products are accounted for by the older persons. Despite this, most of them say that they are not taken into account during products design because products do not adapt to their needs, capacities and facilities and preferences.

To address this problem and include the older persons in the design and assessment of products for their use, the SIMPLIT seal has been founded, developed by the Instituto de Biomecánica (IBV) and the Unión Democrática de Pensionistas y Jubilados de España (UDP). SIMPLIT is the first seal that guarantees that a product is useful, easy and comfortable to use for the majority of people, since they are in charge of evaluating how easy they are to use.

Aligned with this philosophy, awareness-raising, advertising and training campaigns are being undertaken. One example of this is the training initiative detailed below.

The main objective of the "Training of consumer agents for the improvement of quality of life" project was to develop training material that provides UDP executives and members with training on the characteristics that should be considered in the selection of products and services. At the same time, training oriented towards purchasing to improve quality of life is provided, to be aware of the product or service requirements should cover to satisfy their needs and demands. The UDP is a national association of pensioners and retired people founded in 1977 with more than one million members. They engage in activities to help the older persons and are represented in national and international organisations related to the sphere of the older persons.

This training focused on covering the following specific objectives:

- Knowing the purchasing process of five products and the functional, accessibility, comfort and usability requirements they should fulfil to make them easy to use by the older persons.
- Train UDP executives in this topic so they can transfer this knowledge to the other groups of older persons in the UDP.
- Disseminate the SIMPLIT seal among the UDP associates.
Deliver all these contents in a simple and user-friendly way so they can be applied by the older persons in their daily life.

**Methodology**

The methodology used to carry out this project is based on the shopping model (Figure 1), a cycle comprised of four major stages that relate people and products. In each stage, the consumer takes decisions that gradually reduce the number of alternatives to choose from among the different products available. Older persons have to consider a series of questions in each phase of older persons (Figure 2):

**Activation:** The consumer takes the decision to search for, buy and/or use a product. For example, someone may need to buy a mobile telephone because they spend a lot of time outside the house and need to be located by relatives and friends. When this need arises, the consumers must describe the main and secondary tasks that they wish to do with their mobile telephone, such as call, send text messages, charge the battery, take photos, etc.

**Search:** Once the need has been activated, they take the decision to find products to make the purchase. In this stage, the consumer has to take into account the characteristics of the mobile telephone for using without any problems, depending on their skills. They must take into account the phone keypad, screen, audio, battery, operation and instructions. The purchasers make sure that they know all the parts of the mobile telephone and that they can use it in an easily and simply way, as well as the skills needed to use each part of the phone. For example, if the consumer has sight problems they should buy a phone with a suitable keyboard to be able to push the keys without any problems.

**Selection and purchase:** In this stage the consumer makes a decision from a short list of alternatives. At this point in the process, the consumers will be in a store where they have to choose between different mobile telephones and will have to choose the one that best suits their needs. It is good to analyse whether all the tasks selected in the activation phase can actually be carried out and that all the parts of the phone indicated in the search phase can be easily used. Other aspects, no less important, should be also taken into account, such as the return period, the terms and conditions of payment, payment method, the SIMPLIT seal that guarantees that it is easy to use for the majority of people, and the technological and aesthetic characteristics of the mobile telephone.

**Use and evaluation:** Product use gives rise to a degree of satisfaction with the purchase. Once the user has chosen the most suitable mobile telephone, check whether it really is the product they are looking for. For this purpose, make sure that they can perform all the tasks simply, that it meets their preferences, etc. If it is negative, the process can be repeated or they can return to the shop to ask the assistant to deal with any problems that may have arisen, or the phone can be returned if it does not meet their needs.

If the consumer has no problem using the mobile telephone and it fits their preferences, the shopping experience will have been positive.
To transmit the above information, a series of highly useful materials have been developed for both the UDP executives and the remainder older people to facilitate:

- **Learning** documents: An introductory module, modules of five products and an exercise book of these modules. The introductory module provides an overview of the purchasing process of any product according to the consumer’s needs. The modules present the application of the introductory module to given products such as mobile telephones, washing machines, ovens and telecare systems. Finally, the exercise books consolidate the concepts learnt in each module.

- **Support documents** to allow UDP executives teaching the modules: a didactic guide and Power Point presentations. On the one hand, the didactic guide is a document with guidelines for classes, materials to be used, time in each session, etc. Whereas the presentations serve as support for the classes.

- **Simple documents to make easy** the selection of a product in real-life situations: a product data sheet (Figure 3) and an easy guide to select each product (Figure 4). The information data sheet highlights the most important aspects to be taken into account in each stage of the purchasing process and the easy guide helps in the selection and purchase of the product that the older persons person needs to cover their needs, characteristics, etc.

All these documents were used in the training of this project. The training was given in two phases: on the one hand, the training offered by IBV personnel to different UDP executives and on the other the training given by the UDP executives to the members of their respective associations. This training method is **novel and innovative** in this population and the results obtained are very positive since the older persons feel more active and involved in topics which, like this one, have a direct incidence on their daily life.

The IBV gave four training sessions in Alicante, Valencia, Jumilla (Murcia) and Madrid. In these classes, the subject matter was expounded to the different UDP executives so they could understand the contents and be able to teach the contents to the members of their associations. On the other hand, a session was given in Penáguila (Alicante) by a director of the UDP to the other members of the association after the session in Alicante. This session was performed to validate that the materials developed and the course offered were suitable for the executives of the UDP and the rest of the older persons.

Each course, with an approximate duration of four hours, is structured as follows: brief presentation of the course and explanation of the SIMPLIT seal, explanation of the introductory module, coffee break, explanation and practical session with the mobile telephone module and to conclude a brief analysis of the suitability of the services.

**Conclusions**

The contents, materials and the methodology proposed were rated very positively. This assertion is based on the results of the surveys performed after each training session with the UDP executives.

Moreover, the satisfaction of the course attendants was very high, the materials developed and the methodology proposed were rated very positively.

In the sessions given to the UDP executives, 98% agree that the contents were easy to understand. **100% of the respondents stated that they will use this methodology in their next buying** and around 92% of the executives
consider that the material developed to give the classes was very useful.

In the case of the associated who attended the session taught by the UDP director, all they agree with the easiness of the contents developed. 95% of attendants respond that the examples and practical work were very suitable and the general rating of the course was 4.4 in a scale of 5 points.

In the future, the idea is to continue with the training of a larger number of UDP executives, thus also broadening the geographic area in which the training is given, as well as increase the number of products that have specific material developed following this methodology.

ACKNOWLEDGEMENTS
To the Unión Democrática de Pensionistas y Jubilados de España (UDP).
To the Instituto de Mayores y Servicios Sociales (IMSERSO) [Institute of the Older persons and Social Services], an organisation which has supported this project economically.
How can I design products for next season that my clients will fall in love with and remain loyal? This is a question that many companies ask themselves every year. The Instituto de Biomecánica (IBV) has an objective methodology that helps companies to know how they have to design their products and services to satisfy their clients' needs and therefore be more successful on the market. This methodology is People-Oriented Design (POD).

Thanks to this methodology, the EMO company (Especialidades Médico Ortopédicas, SL) has learnt that when people buy textile wristbands and girdles, aspects such as comfort, ease of use and breathability are more important than colour and other image-related/emotional aspects. If an orthosis does not meet these basic functional requirements, the colour of the product will make no difference, because the client simply will not buy it.

Nevertheless, if two products are functionally the same, clients would rather buy a non-sporty wristband in blue or even grey rather than a flesh-coloured one, as this colour is associated with the concept of being old and rather unfashionable.

In the case of girdles, only young people say that they would rather buy a grey girdle first. Older people still prefer flesh-coloured girdles because they are worried about them showing through under their clothes.

With all these data, the EMO modified the design of its orthoses to captivate consumers and create a true love story between brand and clients.

**Bye bye flesh colour**

Nadia Campos Soriano1, Leopoldo Fernández Barrachina2, Ignacio Bermejo Bosch1,4, María Sancho Mollá1, Miquel Cerezo Gandía1, Laura Moreno Sarrión1

1 Instituto de Biomecánica de Valencia
2 EMO, S.L.
3 Grupo de Tecnología Sanitaria del IBV, CIBER de Bioingeniería, Biomateriales y Nanomedicina (CIBER-BBN)

**INTRODUCTION**

EMO (Especialidades Médico Ortopédicas, SL) intends to market a more attractive line of textile wristbands and lumbosacral girdles that its clients will literally fall in love with. More specifically, it wants to know how to design its 2011 collection of non-sports wristbands and girdles in terms of colour, fabric and number of closures to guarantee greater acceptance in demand, and therefore greater success on the market.

**METHODOLOGY USED**

In order to accomplish this objective, the People-Oriented Design methodology of the Instituto de Biomecánica (IBV) was applied.

More specifically, the IBV’s emotional design techniques were used, which enable companies to objectively know how to design their new collections to satisfy their clients’ functional and emotional needs. For this purpose, first of all the criteria (words and expressions) that explain how users perceive the products to be evaluated were obtained. The relationship between the user perception and the design elements of the orthosis being studied was subsequently established. The combination of both phases made it possible to identify which design elements have the greatest influence on the perception of orthoses.

A total of 47 people who use or have used non-sports wristbands and/or lumbosacral girdles in the last six months participated in this study (Figure 1). The sample distribution took patient age into account, since...
this is a variable that has an influence on design preference (Table 1).

Table 1. Sample distribution.

<table>
<thead>
<tr>
<th>NUMBER OF USERS</th>
<th>MEN</th>
<th>WOMEN</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aged 25 to 45</td>
<td>Above 45</td>
<td>Aged 25 to 45</td>
</tr>
<tr>
<td>NON-SPORTS WRISTBANDS</td>
<td>7</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>LUMBOSACRAL GIRLLES</td>
<td>6</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>13</td>
<td>11</td>
<td>10</td>
</tr>
</tbody>
</table>

Products rated:
Non-sports wristbands (Figure 2)
Lumbosacral girdles (Figure 3).

Figure 2. Sample of non-sports wristbands used in the study.

Figure 3. Some examples of the lumbosacral girdles used in the study.
Main results

Thanks to the IBV’s People-Oriented Design methodologies, EMO detected that when buying an orthosis, be it a non-sports wristband or a girdle, users attach greater importance to functional criteria than to emotional and image-related factors.

Comfort is patients' main consideration when it comes to choosing an orthosis. To a lesser extent, it is also important that it is breathable and easy to put on/take off.

As regards emotional and image-related criteria, simplicity, followed by confidence and discreetness, are the most salient aspects.

The most relevant results of the study for non-sports wristbands are outlined below, while the lumbosacral girdles are addressed in a second section.

Non-sports wristbands

Fulfilment of the criteria by each one of the wristbands studied

Wristbands 1 and 2 fulfil all the functional criteria (Figure 4a). Moreover, product 1 is the best-rated in emotional terms by virtue of colour, since it is the only design element that creates a difference between both products (Figure 4b).

Relationship between orthosis design elements and product perception

<table>
<thead>
<tr>
<th>Design parameters</th>
<th>Design-related perception (most significant results)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>The flesh-coloured orthoses (wristbands 2 and 4) are the worst perceived, being rated as the least modern, appealing, fun, sporty and original. Flesh is the colour most associated with the concept of “oldness”. On the other hand, the blue orthoses are best perceived.</td>
</tr>
<tr>
<td>Type of fabric</td>
<td>The foam fabric, also completely lined by a seam, leads the orthosis to be perceived as much more comfortable and pleasant. In the case of breathability and comfort, the foam fabric is also best rated.</td>
</tr>
<tr>
<td>Type of closure</td>
<td>Users want the wristbands to have as few closures as possible. Keep it simple.</td>
</tr>
</tbody>
</table>

Purchase intention and preference

The best-rated wristband is number 1 (Figure 5), followed by 2, 3 and 4

Blue has a more positive influence than flesh on intention to purchase and preference.

If a wristband is not comfortable, users won’t buy it. To achieve this perception the fully coated foam fabric with only two closures should be used.

During the experiment, the users made the following comments about colour:

"The blue seems sportier and the flesh more orthopaedic"

"It needs to be updated and modernised. I like grey and it washes better"

"Blue, purple or black. Not flesh"

"Navy blue because it is more discreet and you don’t equate it with being ill”. Bright colours as well"
Lumbosacral girdles

Fulfilment of the choice criteria for the girdles study

An effort should be made to ensure that the girdles of the 2011 collection are seen to be more comfortable, breathable and easy to clean, since these factors are very important for clients, and, in general, the study girdles hardly fulfil these criteria (Figure 6a).

The flesh-coloured girdles (2, 3, 6 and 7) are more discreet and are less visible under more transparent clothes (Figure 6b).

Girdle 2 is perceived as the oldest, least modern and least elegant.

Relationship between orthosis design elements and product perception

<table>
<thead>
<tr>
<th>Design parameters</th>
<th>Design-related perception (most significant results)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>The flesh colour is the most discreet and less transparent, while the greys (light and dark) are perceived as being sportier. The flesh colour with the green and blue line is the favourite one.</td>
</tr>
<tr>
<td>Type of fabric</td>
<td>The soft fabric of girdle 1 is more pleasant to the touch.</td>
</tr>
<tr>
<td>Type of closure</td>
<td>The girdles with a single closure are easier to put on and take off. On the other hand, those that have a double closure are perceived as the most modern.</td>
</tr>
<tr>
<td>Type of finish</td>
<td>The girdles with a smooth rear finish are perceived as more modern, personalised, adjustable and original.</td>
</tr>
</tbody>
</table>

Purchase intention and taste preference

Although the most important criterion considered in choosing a girdle is comfort, the criterion that ultimately prevails in intention to purchase is colour, followed by ease of use.

The lumbosacral girdles that most users would buy are the flesh-coloured ones. Although a change in clients tastes is afoot, as young people show a greater intention to purchase grey girdles, particularly dark grey (girdle 1)), while the elderly would buy girdle 3, 6 or 7 (all flesh-coloured).

The best rated ones are those with a double closure and smooth rear closure.

Girdle 3, flesh-coloured and with a single closure, best fulfils the criteria of colour and ease of putting on/taking off, criteria which, in turn, largely account for the intention to buy a lumbosacral girdle (Figure 7).

During the experiment, the users made the following comments about colour:

"Flesh-coloured so that it is not visible under the clothes in summer"
"Dark grey, I even like black"
"Flesh, white, even light grey"
"Dark blue"

THE MARKET RESPONSE

EMO modified its old lumbosacral girdles (Figure 8) and launched its new designs for the 2011-2012 season (Figure 9) in July. Taking the recommendations of this study into account, it launched a new line of grey girdles, which have been a huge success. The trend has been inverted. Now 70% of orders are for grey girdles, whereas it only used to be 30%.

EMO thus managed to be perceived as a more modern brand.

As for the flesh-coloured girdles, all the products of the new collection include the blue and green edge and are manufactured with the foam fabric which the participants in the project liked most.
The products were designed with the fewest possible number of closures, depending on the condition, with velour reinforcement, fitting user preferences.

**Conclusions**

People-Oriented Design methodologies allowed EMO to ascertain how users perceive its products and how it has to design the orthoses of its next collection to make clients fall in love with them. Now it knows what aspects of design it has to focus on, invest in and pamper to captivate consumers. If an orthosis does not deliver the basic functional aspects of comfort, breathability and ease of putting on/taking off, color makes no difference as the client will simply not buy it.

In the case of external orthoses, such as textile wristbands, it is time to expand the colour pallets and offer clients colours other than flesh, such as blue, dark grey, light grey, black, etc. The patients will be delighted.

In the case of under-the-clothes orthoses, such as girdles, only young people say that nowadays they would be willing to buy a grey girdle first. Most prefer the flesh colour because it is not visible under clothes, although colours such as light grey can also serve these purposes.

In terms of closure, in both cases the clients prefer the “keep it simple” concept, i.e. the fewer closures/Velcro the orthosis has the easier it is to use and therefore the easier it will be to put on and take off.

Regarding fabric, in the case of the wristbands it is clear that users prefer the foam fabric because the orthosis is more comfortable and pleasant.

Thanks to People-Oriented Design, EMO listened to the voice of its clients in its designs, empathising with them and responding to their functional and emotional needs. The increase in sales of the products developed using this methodology endorses its validity. A guaranteed love story.
Good practices for adapting jobs for older people

In the coming years, companies will see how the age of their workforces increase due to the age evolution in our society. In view of these changes, and with the objective of promoting health and quality of life as well as guarantee productivity, workplace requirements have to be adapted to the evolution of worker skills. This article shows an approach to how workplaces have to be designed for older workers.

**Introduction**

Because of the demographic evolution and the improvement in quality of life in the European society, the average age of the population, and therefore workers in companies, is increasing rapidly. Although many older workers can do virtually all of their tasks satisfactorily, the natural aging process leads certain physical, sensorial or cognitive abilities to be impaired.

Older workers can partially compensate for these difficulties by providing their experience and specific skills that young workers do not have. But to do so, companies should take into account the variation in the skills of workers, and promote adaptation to demands to optimise both their quality of life and productivity.

Hence, it is essential than companies know the basic criteria to design and organize workplaces based on aspects such as: environment, cognitive, workload, etc.

With this objective, the Instituto de Biomecánica de Valencia, with the support of the Ministry of Economy, the Treasury and Employment of the Autonomous Government of Valencia has developed a good practices guide for the Adaptation of workplaces for Older Workers that seeks to offer recommendations to configure suitably workplaces and maximise health, safety, comfort and the efficiency of older workers.
Development

To develop the guide, a structure which initially describes the main effects of the aging process, and how they affect the skills of the people for doing their work is proposed. This is followed by a proposal of a series of general principles that should always be taken into account when thinking about how well workplaces and worker capacities are matched to each other. Finally, the different sections address recommendations that should be taken into consideration to create a good workplace from different standpoints.

The process of aging at work

Aging is the set of morphological, physiological and psychosocial modifications that appear as a result of the passing of time. The effects of aging are different in each person, and above all according to their vital history. Nevertheless, some aspects that are usually common to aging are related to the following aspects:

- Progressive loss of visual capacity: reduction of visual acuity and visual field, diminished ability to adapt to contrast, colour and dazzle, etc.
- Progressive loss of the sense of hearing: presbycusis is characterised by a gradual but significant loss of hearing that affects all frequencies.
- Reduction in muscle functionality that affects the ability to adopt extreme postures, carry out repetitions and apply strength, mainly:
  - Loss of muscle elasticity.
  - Growing distension of muscle support tissues (loss of muscle tone).
  - Progressive loss of muscle strength and vitality (25% reduction of muscles strength at the age of 60 versus 20s).
- Loss of agility and reflex reaction capacity.
- Loss of the ability to associate ideas.
- High blood pressure.
- Reduction in immune capacity against contagious agents.

All these effects present a series of challenges from the entrepreneurial standpoint to accomplish the double objective of promoting health and encouraging worker skills according to different aspects:

- Promote healthy aging.
- Adapt the demands of work so that they will adapt to the evolution of the worker skills in the aging process.
- Promote the transfer of knowledge that older workers accumulate to become an asset in the company.
- Promote mentoring programmes of young workers by older workers to accelerate their process of learning while also promoting intergenerational groups in which each one gives the best of their abilities.
- Facilitate older people’s adaptation to change, both for the incorporation of new technologies and the modification of tasks.
- Help workers to prepare for an active and healthy retirement.

Good practices to be applied in the company

As a worker gets older, the company should address the following aspects related to the demands of their job.

1. Aspects related to the design of the work station.
   a. The worker’s exposure to environmental factors such as noise, temperature, vibrations, etc. should be taken into account
   b. Proper Lighting and contrast will make it easier to read texts and signs in workplaces. Besides, size, colour or duration of signs should be optimised.
   c. Acoustic conditions in work areas should be adapted, making the relevant sound signals easy to hear and reducing levels of noise that affect concentration and health.
   d. The anthropometric changes that affect elderly, and which affect the design of a job or workplace, its scope and mobility, should be addressed.

2. Aspects related to job contents.
   a. From the standpoint of cognitive ability, levels of demand should be adapted to worker skills, paying special attention not to create confusion among demands, avoiding complex choices in short time intervals, a surplus of irrelevant information, the high level of memory requirements or interruption.
   b. From the standpoint of physical burden, special care must be taken with the main risk factors of musculoskeletal disorders (repetitive jobs, awkward postures, manual handling and strength applied).

3. Aspects related to the organisation of work, pertaining to the type and variety of tasks, at the pace and timetables or demands of participation, training and recognition.
4. Aspects related to promoting worker skills through promotion and prevention programmes of health, training programmes, good business practices or support in the transition towards retirement.

**Conclusions**

Thanks to the preparation of this good practices guide for the adaptation of workplaces to older workers, the Instituto de Biomecánica is providing to company occupational risk prevention and human resource managers with a set of recommendations for adapting employment demands to the skills of older workers.

This initiative thus aims to be an initial approach to cater to a growing need in companies associated with the demographic changes that are bringing about an increase in the average personnel age.

**Acknowledgements**

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Good practices at the chemical industry to prevent risk of shift work in elderly workers

Alberto Ferreras Remesal, Alfonso Oltra Pastor, Rakel Poveda Puente, Raquel Ruiz Figueroa, Clara Bollaín Pastor, José María Baydal Bertomeu, Juan Fayos Sancho, Juan Alfonso Gómez Herrero

1 Instituto de Biomecánica de Valencia
2 Grupo de Tecnología Sanitaria del IBV, CIBER de Bioingeniería, Biomateriales y Nanomedicina (CIBER-BBN)

INTRODUCTION

The aging process in industrialised countries is bringing new challenges for governments and companies alike. The effect of increased life expectancy, together with a reduction in turnover, calls for a reconfiguration of company workforces. This reconfiguration in the organisation of work must be based on the adaptation of jobs to worker skills, thus optimising their performance and productivity.

This reasoning is particularly important in sectors with jobs whose physical and psychosocial demands are high. Sectors where there is a high presence of jobs that require shift work are a clear example of this. The chemical sector, where more than 40% of the workers do shift work, is, together with the metal, health and social services sectors, one of the branches with the highest percentage of this type of jobs. Moreover, a quarter of these workers do night shifts.

There is an abundance of epidemiological literature that demonstrates the negative impact of shift work on people’s health. In the short term, the main effects are due to problems related to changes in biological rhythms and their multiple consequences (sleep, nutritional disorders, psychosocial risks...). In the long term, night work or alternating shifts affect workers’ health, working conditions or social and family relations.

This is why it is very important to develop preventive instruments to inform the companies in the chemical sector about the risks older workers face in shift work, as well as to disseminate good practices that will help to reduce these risks to workers through the latter’s participation.

This project was developed by researchers of the Instituto de Biomecánica (IBV) in collaboration with professionals of the Federación de Industria Textil-Piel, Químicas y Afines de Comisiones Obreras [Federation of Textile-Leather, Chemical and Related Industries of Workers’ Commissions] (FITEQA-CC.OO), la Federación Estatal de Industrias Afines de UGT [State Federation of Related Industries of UGT] (FIA-UGT) and the Federación Empresarial de la Industria Química Española [Entrepreneurial Federation of the Spanish Chemistry Industry] (FEIQUE). The contents were developed within the framework of the IS-0140/2010 Project, with the funding of the Fundación para la Prevención de Riesgos Laborales [Occupational Risk Prevention Foundation] (2010 call for resource allocation).
Development

The following workplan was applied to fulfil the project objectives:

Phase 1. Documentation review and planning of the field study

This phase was intended to compile the essential documentation that addresses the project’s three thematic axes (chemical industry + older workers + shiftwork). The core activity was a documentary revision on previous studies related to the risks associated with shiftwork, as well as the good practices recommended for adapting jobs to older workers.

Besides the compilation of bibliographic information, the most representative standard jobs in the sector were defined to focus the study and subsequent results.

Finally, the information compiled in this phase was used to prepare the data collection instruments (discussion group questionnaires and scripts) that were used in phase 2.

Phase 2. Development of the field study

This phase was used to collect direct and relevant information from the agents involved in the project objective: workers and their representatives, production managers, human resource managers, prevention managers from the chemical sector, etc.

Discussion groups and questionnaires were held in this phase. The following aspects were addressed in both cases:

-- Identification of jobs involving shift work.
-- Definition of shift organisation and characteristics.
-- Problems detected in work shifts, making a distinction between young and older workers.
-- Adaptations or modifications made to improve working conditions in shifts and adaptation of the job to older workers.

Discussion groups: The discussion group is a technique that makes possible to deal broadly with a series of topics and to compare the different standpoints and points of view.

In this project, four discussion groups were held, in Madrid, Tarragona, Seville and Valencia. Each group lasted 2.5 hours. Managers, technicians and workers from different companies in the sector participated in the groups.

Questionnaires: Two surveys were drawn up: one for technicians and people in charge of the management, organisation or administration of shifts, and another survey for chemical industry workers. Fifty (50) and 254 questionnaires, respectively, were collected. The high participation rate of companies and workers yielded highly interesting results for the project and which reflect the organisation of shift work, its impact on workers (particularly older workers) and improvement proposals.

The results obtained in this phase were added to those obtained in phase 1 to prepare the different materials.

Phase 3. Field study results report

A technical report was drawn up with the main study results, constituting the basis for the elaboration of information on good practices addressed in this project.

Phase 4. Preparation of information and awareness-raising material

The results of phase 3 were used to prepare a manual and a leaflet analysing the risks faced by older workers in the organisation of work shifts at the chemical sector, offering recommendations for improvement.

Phase 5. Assessment of finished products

The objective of this phase was to verify the efficacy, applicability and efficiency of the products developed in the preceding phase through the assessment of an expert group.

Phase 6. Dissemination

The objective of this task was to spread the results of the preventive action performed and take the end results to the users.

The main targets of the results and materials prepared are the workers of the chemical industry sector (and their representatives in occupational risk prevention matters).

The following dissemination actions were addressed:

-- Distribution of the material elaborated among companies, unions and associations.
-- Presentation day of the results of the action.
-- Publication in magazines specialising in occupational risk prevention.
-- Publication in sector magazines and journals.
-- Dissemination through the websites of the IBV, FIA-UGT and FITEQA-CCOO and FEIQUE and attached organs.

Conclusions

The information obtained in this project refers to two of the most frequent and important challenges currently faced by companies from the chemical sector:

-- Aging workforces. Older workers are an increasingly bigger group in chemical companies. A suitable management of their skills and experience, as well as the adaptation of jobs to their skills and needs, are challenges the chemical sector has to face.

-- Shift work. Forty-one percent (41%) of workers in the chemical sector work in shifts and 22% includes the nightshift. This figure amounts to 46% of older people above the age of 55. This situation causes problems in aspects such as adjusting to skill, health and work-life balance.

The information obtained makes it possible to draw the following conclusions:

-- Shift work is characteristic of the chemical industry sector, and its incidence on workers, particularly as they get older, has been demonstrated in the course of this study.

-- Demographic changes are leading the shiftwork+older worker binomial to take on increasingly greater importance
Projects in the chemical industry. This is why it is very important that companies implement measures that take into account the progressive aging of the workforce in order to, on the one hand, avoid risks, and on the other to promote the advantages of experienced workers.

Moreover, measures that mitigate the impact of shifts on older workers must be planned, agreed to by consensus and tested. These measures must be based both on improving working conditions (environmental, ergonomic, workload, breaks, etc.) and on the structuring and organisation of shifts (type of rotation, restrictions, etc.). One key aspect is that all workers must be involved in all the designs that are applied:

- First of all, it is indispensable that everyone involved in the preparation of proposals and the organisation of working conditions participate as far as possible: consultation on alternatives, creation of improvement groups, etc.
- Consider the workforce in each company and its social and family conditioning factors (and age of course) when designing work organisation.
- Think over workers’ opinion after every modification or improvement to evaluate their impact and effectiveness.

- One of the most called-for improvements is related to the establishment of a reduction coefficient so that workers who have worked shifts can take earlier retirement. This recommendation is clearly logical as soon as we consider the increase in the risk involved in shifts as people get older, as can be seen in the study results. Nevertheless, it is a recommendation that is difficult for companies to apply, but rather depends on other factors such as collective negotiation and social and labour policies. In any case, and regardless of whether or not they can be applied, there is a need to implement effective measures for the reduction in the risk of shift work. In this project, different proposals targeting a joint approach were made:
  - The ergonomic improvement of working conditions involving shifts, since the reduction in the physical burden has a positive impact on health and productivity and mitigates the impact of shifts.
  - Measures to adapt jobs to the characteristics of older workers.
  - Actions to improve the organisational aspects of work, shiftwork and the conditions in which these shifts are implemented.

All the information can be queried and downloaded from the website: [http://quimicas.ibv.org/](http://quimicas.ibv.org/).

**Acknowledgements**

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e-learning Project about osteosynthesis and fracture management

Stefano Deotti, Joaquín López López, Arturo Gómez Pellín, Carlos Atienza Vicente, Beatriz Mañas Ballester, Francisco Matey González, Juan Fernando Giménez Pla, Miguel López Torres

1 Instituto de Biomecánica de Valencia
2 Grupo de Tecnología Sanitaria del IBV, CIBER de Bioingeniería, Biomateriales y Nanomedicina (CIBER-BBN)

INTRODUCTION

Osteoporosis is a disease that affects mainly elderly people and is the most common cause of fractures. As a consequence of an aging population and increased life expectancy, a substantial increase of fracture cases in the coming years is forecast. In this context, the manufacture of implants and orthopaedic surgery and traumatology (OST) have become disciplines with a clear growth potential.

In the course of 2008, approximately 420,000 surgical procedures using implants were performed in Europe, with a related expenditure of more than 4,800 million Euros. A significant percentage of this number (15%, 720 million Euros) was due to errors in the diagnosis of the fracture, implant selection or preoperative planning.

These facts have given rise to different changes in the OST Sector, particularly:
- The need for a greater number of trained professionals to cover the growing demand in this field.
- Greater patient pressure to improve quality and avoid errors.
- Emergence of new techniques and new implant models, many of them unknown to surgeons.

Moreover, attention must be drawn to the most significant conclusions of the eTEN market validation project ORTHOSIM (the European Simulation Service Provider for orthopaedic surgery), which demonstrates the interest of the main market agents to have an online training solution based on the simulation of clinical cases. The OSTEOFORM project (www.osteoform.org) made it possible to satisfy this demand from surgeons, biomedical engineers and research and teaching personnel through the start-up of a telematic training tool that combines aspects of general training in orthopaedic surgery and traumatology, biomechanical aspects related to osteosynthesis, surgical implants and new diagnostic and clinical planning tools.

The project, co-funded by the Leonardo Da Vinci Lifelong Learning Program 2007-2013, featured the participation of the BGU Murnau (Germany) and Komag (Poland) research centres, the Fundación Teknon of Barcelona, the Spanish Federation of Health Technology Companies (FENIN), the Polytechnic University of Valencia - through the Postgraduate Training Centre - and the company Adapting S.L.

OBJECTIVE AND PHASES OF THE PROJECT

The main objective of the project was to develop a course on the biomechanics of fractures and osteosynthesis techniques for professionals both from the medical sector specialising in orthopedists and...
traumatology and the implant and surgical instrumentation manufacturing sector (Figure 1). To achieve this objective, a two-year work plan was established, envisaging four technical phases.

1. Detection of potential users’ training needs

In this phase, the specific training needs in Europe of the groups targeted by the course were evaluated:
- Health institutions (Public or Private).
- Implant manufacturers (R&D Department, Commercial Department).
- Research and Development Centres.
- Universities and Lifelong Training Centres.

For this purpose, a survey was conducted using an analysis methodology, expressly designed by the IBV experts. The results rendered it possible to define the learning objectives, define the corresponding course training modules and select content sources.

2. Adaptation and integration of training contents

The second phase of the project entailed the performance of important work to adapt the training contents and the making of the course modules, integrating the theoretical and practical parts according to a specific didactic system for online training. In this phase, the experts on biomechanics and osteosynthesis surgical techniques of the consortium worked together, pooling their knowledge and revising the training material to obtain a consistent and exhaustive ensemble.

With regard to practical aspects, a training tool for the classification of fractures was integrated in the course (Figure 2). The use of this tool allows surgeons to improve their capacity to make a correct diagnosis, thus reducing operating planning times. A module on osteosynthesis surgical treatment simulations based on finite element models was included (Figure 3). These models promote understanding of the biomechanical concepts that govern osteosynthesis processes; particularly those based on the use of implants. The application of these concepts will enable surgeons to reduce surgery errors, thus reducing the risk of failure, and engineers will be able to optimise the design process of implant for the treatment of fractures and obtain more reliable and less costly designs, ensuring that they operate properly.

3. Development of the online course

Once the contents had been developed, the course was implemented online on the project’s telematic platform (www.osteof orm-campus.adapting.com), obtaining an accessible remote training tool for any European professional and student. The course was given in English and in the partners’ different languages: Spanish, Polish and German.

4. Making of a pilot course. Validation

Finally, the tool developed was evaluated by means of a pilot course with end users from the different countries of the project partners. The pilot course allowed validating the suitability of the online course for learners’ skills and needs, both in terms of theoretical and practical contents and in terms of the general structure (Figure 4).
CONCLUSIONS

The result of the OSTEOFORM project is an online training course dedicated to the biomechanics of fractures and osteosynthesis techniques targeting the professionals of the medical sector specialised in Orthopaedics and Traumatology and the implant and surgical instrument manufacturing sector.

This course includes didactic material from different leading European centres and enables users to obtain medical and engineering knowledge. Training contents are adapted to user needs and the didactic methodologies that were used to prepare them help learners to make the most of the course. Moreover, in using biomechanical simulation models, the practical cases will enable the user to clearly and visually understand the theoretical contents, reinforcing them.

This new tool, available in four different languages (English, Spanish, French and German), will guarantee access to lifelong training in the sphere of OST and will offer innovative and relevant contents that will allow users to be better trained to practice their profession.

This course will become part of the IBV training offer through the virtual education campus (http://campus.ibv.org/), where the following related courses are already available: Clinical Biomechanics, Update of biomechanical fundamentals of locomotor apparatus surgical techniques, biomechanical fundamentals of spine surgical techniques and Biomaterials.

ACKNOWLEDGEMENTS

To all the project partners (BGU Murnau, Komag, Fundación Teknon, FENIN, CFP-UPV, Adapting S.L.).

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Incorporating user feedback into design, a new methodology

Juan Vicente Durá Gil, Jaime Díaz Pineda, Elisa Signes i Pérez, Helios de Rosario Martínez, Enric Medina Ripoll, José S. Solaz Sanahuja, Lourdes Tortosa Latonda, Mª José Vivas Brosra

Instituto de Biomecànica de Valencia

INTRODUCTION

Nowadays, markets are very dynamic, there is great pressure in price-fixing, and client needs are changing all the time. Technical excellence is no longer enough to get clients interested. For this reason, the early detection of client needs with regard to their emotions and perception, as well as their efficacious application to product characteristics, are an opportunity, and also a challenge, for companies to stand out from their competitors. The assumption that products are useful, usable and lasting does not suffice to guarantee success. To this end, different kinds of questions must be answered, such as:

-- How do new products affect users’ emotional aspects?
-- What designs are good in guaranteeing the success of future products?

The answer to these questions lies in extending the definition of product quality, including the ability to satisfy clients’ emotional needs, taking their lifestyle and values into account. Clients’ subjective perception of a product’s quality is basic in their deciding to buy it. For this purpose, companies have to generate products that the client rates positively from the early design phases.

However, we lack methodologies that allow us to address this problem scientifically and systematically.

At this moment in time, the most common method of evaluating client perception is the use of different types of questionnaires in which the client states their opinions. This method is a self-assessment that only measures the conscious part, and is evidently insufficient. The self-assessment is subjective, and is limited to a subset of the conscious feelings which can be accessed by the cognitive processes of representation and self-control. However, unconscious psychological processes may occur independently of conscious feelings. And these unconscious processes entail reactions that can be observed physiologically.

Moreover, a subjective self-assessment does not provide information while the product is actually being used, it is an assessment made a posteriori by the client.

It is known that different product designs can have an influence on a user’s psychophysiological response, which can be measured through records of skin conductivity, facial electromyography, heart rate, etc. The advantages of these physiological measurements are:

-- Measurements can be taken continually with a high time resolution.
-- They are objective.
-- The measurements provide indicators of mental states, including emotion.
They provide information about unconscious emotional states.

They can be related to product or service design parameters.

Currently there are technologies that can measure physiological signals. However, the different technologies have to be combined and fine-tuned to afford a reliable assessment of products and new designs. Moreover, the results must be part of an integrated and reliable product development process.

The main objective of this project is to make progress in objective measurements related to the product and service evaluation process. The innovation of this project is the fine-tuning of the technology that can objectively evaluate the client’s perception. This new technology will be available to the needs of industry, particularly SMEs.

**Work performed. Preparation of the laboratory**

The CONEMO project was approved in the 9th CORNET (Collective Research Networking) projects call, including the participation of FQS (German Society for Quality) and WZL (Machine-Tool and Production Engineering Laboratory) of the University of Aachen (Germany). It features the collaboration of five SMEs from the Autonomous Community of Valencia and five SMEs from Germany, forming the project’s user committee.

The project is currently halfway through its development, and is scheduled to be completed by the end of 2012. To date, progress has been made in fitting out the laboratory for the analysis of physiological signals. This laboratory boasts a series of measurement tools that use:

- Galvanic Skin Response (GSR).
- Facial electromyography to measure the activation of the zygomatic and corrugator muscles.
- Heart Rate Variability (HRV).
- Gaze monitoring.

In the course of this first phase of the project, these techniques were fine-tuned by means of tests in the laboratory of the Instituto de Biomecánica (IBV). By way of example, the following images show the placement of sensors on the face (left) and the activation of the facial muscles (right).

These techniques can classify the emotions of users when they are looking at or using a product. Emotions are classified according to their intensity or level of activation and valence. Something appealing will display a positive valence, while a product or a situation that causes aversion will display a negative valence. This renders it possible to classify emotions in four quadrants and analyse the effect of designs on clients and users (Figure 3).

While emotions are being analysed, the laboratory also allows us to monitor the user’s gaze, thus ascertaining which part of the design the user was looking at. Figure 4 shows the result of this type of analysis. The areas in red are the ones which the user looked at longest.

**Work performed: Product strategy**

Parallel to the fine-tuning of the laboratory, and in collaboration with the companies that participate in the user committee, a series of practical cases are being to use the measurement of emotions during the design process. The methodology used is based on:

1. Analysing the strategies of the collaborating companies. The aim is to define the type of perception to be conveyed to the clients and collate this information with what the clients expect.
2. Defining product structure by means of:
   2.1. An analysis of the functions to be fulfilled by products.
   2.2. Defining product structure (the parts).
   2.3. Relating functions to parts.

This work is being conducted in collaboration with:

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Once the product strategy has been defined, different design options will be analysed in the course of 2012 to verify the practical application of the techniques that have been fine-tuned in the laboratory.

**Conclusions**

As an end result of the project, at the end of 2012 a guide will be published, intended for small and medium-sized companies, which will allow them to use these methodologies in their new product design and development process.

Further information can be obtained on the project website [www.conemo.ibv.org](http://www.conemo.ibv.org).

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