

Postural Comfort Inside a Car: Development of an Innovative Model to Evaluate the Discomfort Level

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ABSTRACT

How can car designers evaluate device's position inside a car today? Today only subjective tests or "reachability" tests are made to assess if a generic user is able to reach devices, but it's no longer enough.

The aim of this study is to identify an instrument (index) that is able to provide a numerical information about the discomfort level connected with a posture that is kept inside a car to reach a device, by this instrument it should be possible not only judge a posture, but also compare different solutions and get rapid and accurate evaluations.

In the state of the art there are many indexes developed to evaluate postural comfort (like RULA, REBA and LUBA [3, 4, 5]) but none of them has been realized to evaluate postures' conditions that can be detected inside a car, so their evaluations cannot be acceptable. There are also many other studies (like Porter and Gyi, Krist, Grandjean, Rebiffe, Dreyfuss 2D and 3D) which deal with postural comfort inside car, but they have only assess neutral angles and ranges of comfort, so their evaluations are qualitative and discontinuous.

For these reasons it has been realized a new instrument (implemented by our research group using Matlab™) to give the wanted numerical evaluation; it is based on an human scale manikin that can reproduce each user and each posture which can be introduced directly or imported from a digital human modeling (DHM) software (like JACK™ developed by U.G.S.), on discomfort functions (one for each degree of freedom of the manikin) and on a method (based on the distribution of the weights of the human body on the different joints) to aggregate them and return total discomfort values.

INTRODUCTION

Nowadays the automotive is strongly computerized, before that a simple bolt has been built or bought a modern car already exists, as well as in someone's head, in a virtual environment where it's possible to realize analysis and studies as on a real one.

Thanks to CAD modeling it's possible:

- ▣ to make changes according to our will in an immediate and simple mode and without costs (before any changes were made physically, so with long time and significant costs),
- ▣ to realize structural checks,
- ▣ to simulate tests (such as crash test and so on),
- ▣ to study the interaction with humans: this is possible by using:
 - virtual human-scale mannequins or
 - virtual reality devices, that are able to connect directly a person with the CAD model of the vehicle.

This aspect is what the manufacturers are focusing on to provide a further added value to their product in order to be able to build something that, in addition to performance, also provides good feelings and a sense of pleasure by using it, in few words: Comfort. To do this, and keep everything still in a virtual environment, it's necessary to impose a criterion that would extrapolate feelings' information from geometric information (user's posture and devices' position). There are a lot of criterions, but many have been designed for other areas (like RULA for repetitive tasks' analysis); many provide

just a qualitative assessment (good, fair ...) and others provide only a situation of comfort or less of the manikin in some considered joints.

The aim of this study is to identify an instrument/index, that is able to give a numerical indication of the comfort degree associated with a posture, in order not only to judge it, but also to compare it with others and to allow more accurate assessments.

On this way we tried to understand if there is already something similar, which criteria, among the existing ones, is translatable in the studied scenario and to sum all in order to obtain an index that can provide the wanted results and, at the same time, that is agree with the instruments which are currently used for the same purpose.

STATE OF THE ART

We have found many studies in this area: Dreyfuss [1], Rebiffe (1969), Grandjean (1980), Krist (1984) and Porter (1998) [2], just to name some that have focused their attention on the comfort inside car. These, by experimental or theoretical way, have reduced human posture to series of simple positions of some joints and have researched the limits within each joint's position can be considered in comfort (Fig.1). This approach shows that their goal was to simplify the posture and to define areas of acceptability; in our opinion, this is the way to follow because it seems the best one for helping us to obtain an overall judgment on a posture or to compare different postures. The basis of these criteria is to find an optimal posture, summarized in a list of comfort angles on which the acceptability's ranges are centered and the evaluation of the angles, that describe the posture; an indication of discomfort is the result of a comparison with nominal postures and these defined ranges.

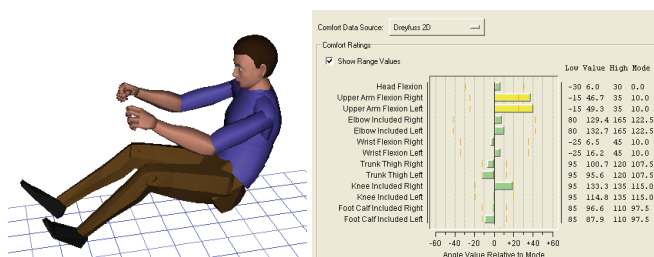


Fig.1 - Posture "drive" by Jack and Dreyfuss' evaluation

We have investigated among studies and papers but we've not found this researched instrument, so the attention has been shifted upon similar ones that are used in different areas; we have analyzed three of them: the RULA, the LUBA and the REBA; these three instruments evaluate a posture and give in output just a single value to describe it.

The Rula (Rapid Upper Limb Assessment) is a tool developed by the University of Nottingham (McAtamney and Corlett, 1993) and allows to get an easily quantifiable value of the musculoskeletal load connected with a specific task; in particular it deals with the upper body and the output is a value that indicates the risk's degree (and with it, the need for intervention) due to studied posture, loads and movements [3]. Its use is indicated to assess posture relative to sedentary tasks such as those that include the use of a screen or a computer or those in which you are sitting or standing without big movements; its main applications are:

- Measure of risk musculoskeletal;
- Comparison of the load for different postures;
- Evaluation of productivity and convenience of equipment;
- Education of employees about the risks caused by different postures of work.

This analysis suggests that the posture inside car is similar to the postures this index has been realized to evaluate, but the RULA is for repetitive task and inside a car each movement isn't so frequent to be considered repetitive, and there are no loads as in a common task, so the result of its evaluation of a posture inside car can't be acceptable.

The REBA (Rapid Entire Body Assessment, Hignett and McAtamney, 2000) was developed to estimate the posture of unpredictable work in health care and similar, it's based on a collection of data on body postures, forces used, movements and repetitions, and the final score indicates the level of risk and urgency of an intervention [4]. The initial development of the method is based on the angular range proposed by Rula and on the anatomically neutral posture proposed by 'The American Academy of Orthopedic Surgeons' (1965) and the risk arising from a deviation from it. This method is also based on 144 combinations of postures and on the judge that a group of physiotherapists/ergonomic has given for them, so the studied posture is evaluated by the score of one of these combinations.

The Reba can be used when:

- the whole body is involved;
- the posture is static, dynamic, rapidly changing or unstable;
- the posture is frequently subjected to animated or inanimate loads;
- we have to monitor the risks related to changes in behavior, equipment or workplace.

The bases of this method are qualitative assessments given in a continuous and repetitive work and therefore valid only when we found in the same conditions of evaluation (or at least when we approach them).

The LUBA (Postural loading on the upper body assessment) is the result of a collaboration of the