International Doctorate in Civil and Environmental Engineering

Inclusion of Human Factors principles in road design to improve road safety

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Abstract/Research Project Presentation

"Human-factors engineering, also called ergonomics or human engineering, is a science dealing with the application of information on physical and psychological characteristics to the design of devices and systems for human use. As a body of knowledge, human-factors engineering is a collection of data and principles about human characteristics, capabilities, and limitations in relation to machines, jobs, and environments. As a process, it refers to the design of machines, machine systems, work methods, and environments to take into account the safety, comfort, and productiveness of human users and operators" (Alphonse & Holstein, 2018).

In the past many errors that were made, were addressed to the error of a person or a little group of people, not understanding that the cause could be an error induced by a human limitation. Today all the engineering disciplines are facing the issue: engineers must solve the problems of integrating humans into machine systems by rigorous scientific methods and not rely on just logic, intuition, or common sense. The *road infrastructures system* can't ignore this.

Road safety is still one of the most relevant cause of deaths around the world. During the first days of the new millennium this concept has become evident, translating in the concept of the Safe System. The Safe System considers human errors and so the occurrence of an accident, unavoidable. Thus, the safe system approach marks a shift from a sole focus on crash reduction to the elimination of death and serious injury (PIARC - World Road Association, 2015). Understanding and applying Human Factors principles to road design will help to reduce both the whole number of accidents occurring on roads and the severity of those accidents. This is because driving is an action strongly linked to

human's perception and analysis capabilities, because driving is both a sight based and an experienced based procedure. This means that drivers are mainly influenced by what they see (road and road environment) and what they have seen. These two concepts must be considered in road design. Applying Human Factors principles in road design means that a road must be **self-explaining**: the driver must understand which the right behaviour is under that conditions, without any other help. Achieve such a goal is quite impossible, however it is possible to design roads that are easily understandable. The relationship between road design, road safety and human conscious and unconscious behaviour is the key to reach that objective.

Up to now Human Factors has been used within road design and road safety under three main principles or rule (PIARC - World Road Association, 2016):

1. **Optical guidance**: the road should give users enough anticipation time at critical decision points (junctions, sharp bends, pedestrian crossings, bus stops, driveways etc.) to perceive and adapt their driving behaviour to the changes in the road course (the "4-6 seconds" rule);
2. **Spatial perception**: The structure and organization of the roadside and of the surrounding landscape should lead drivers to choose the appropriate speed and to stabilize lane tracking (the "field of vision" rule);
3. **Driver's expectations**: the road should pre-program the driver's actions correctly and respect their expectations formed by their recent perceptions (the "logic" rule).

What is required now is to try to translate in an engineering language, concepts that are currently mainly based on logic, intuition or common sense. Many legislations around the world have started considering the Human Factors principle during the road design process. The unconscious processes are regulated autonomously by the brain on the basis of previous cognitions and perception of the visual framework (*Gestalt* concept) that come from sight. So, the proposals are to identify what is the relationship between Field of View (composition, colour, shape, contrast, optical density, etc.) and driving behaviours. Many questions required an answer: what is the role of experience? Do routine and consuetude effects reduce effectiveness? How can the driver shift from unconscious to conscious driving? What is needed to be included into the visual framework to facilitate the transition?

To answer those questions, the objectives are:

- Identify the transversal requirements needed to convert psychological studies in engineering measures. This is the main purpose, but also the hardest to reach because of the complexity of the argument. The scope is to identify the reasons for the manifestation of certain behaviours and the cause-effect mechanisms that regulate man-road interaction.
- Defining engineering procedures that allow the use and application of Human Factors principles in road design. After understanding the process that regulate man-road interaction, the research project wants to identify the procedures that allow the use and application of Human Factors principles in road design (or implement the ones that already exist).

Those objectives should be achieved by different steps: the first stage will focus on the

study of how human behaviours operate, particularly on how they are influenced by the field of view composition and so by the visual perception (*Gestalt*). To perfectly complete the first stage, it is essential to cooperate with other research teams and also with psychologists and neuroscientist. The synergy between the world of engineering and the world of psychology and neuroscience can give a strong impetus to this research.

During the second stage, it is necessary to identify the procedures that allow a quantitative representation of the "Human Factors conditions" (i.e. a score to classify road segments based on Human Factors parameters). After the identification of an engineering approach and rules, the third stage of the project will develop by analysing the application of the results. The LaSIS simulator of the University of Florence, could be an effective instrument to validate the results and to support new researches. Another way to validate the results could be based on real human behaviours on existing roads. Florence Municipality (Comune di Firenze) and Tuscany Region Administration (Regione Toscana) have always collaborated with the Department of Civil and Environmental Engineering of Florence University (DICeA), so the possibility of a new collaboration is a concrete option.

The fourth stage is the summary of the previous stages and its aim is the creation of suggested procedures to include Human Factors in road design RSA and RSI to improve road safety. This coincides exactly with the new European directive about road safety, that focus on a more pro-active approach in order to identify critical road segments before an accident occurs.

The last stage is the composition of the PhD thesis where all the results will be summarised.