There's more to safe driving than information and decisions

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Abstract

Almost from the invention of the motor vehicle the measurement of human performance has progressed in tandem with the measurement of the vehicle itself. Ergonomic research has measured and modelled many human capabilities including reaction times, task loadings, human error and human situation awareness. Most ergonomic studies have however been performed using highly specific scientific tests in either the laboratory or on the road, whose results, while correct, are not generalisable. This paper discusses the distinction between “human performance” and “human behaviour” and the benefits of a more behaviour-based approach to vehicle design and driving safety. Two emerging human centred design concepts are introduced which are called “naturalness of interaction” and “emotional safety”, and a basic definition of each is provided. Observations are made regarding why the two concepts are emerging as focusses of human centred design research, and regarding what potential benefits their development might bring.

Introduction

Almost from the invention of the motor vehicle the measurement of human performance (Meister 1999) has progressed in tandem with the measurement of the vehicle itself (Bhise 2011). For example, driving simulators of the type shown in Figure 1 were used in the 1920s and 1930s to measure human responses such as steering accuracy and brake reaction times.

Figure 1) Early driving simulators (http://uk.groups.yahoo.com/group/Idaman_Group/message/52654).

Over the years ergonomic research has measured and modelled many human driving capabilities including reaction times (Peacock and Karwowski 1993), mental workload (Peacock and Karwowski 1993), human error (Fischer et al. 2011) and human situation awareness (Gugerty 1997). Most studies have been performed using highly specific scientific tests in either the laboratory, on the test track or on

the public road, whose results, while correct, are not always generalizable. In recent years motor vehicle manufacturers have been deploying the emergent paradigm of human centred design in order to better understand the needs and behaviours of drivers within the more realistic context of their normal driving.

From Ergonomics to Human Centred Design

Human centred design has its roots in semi-scientific fields such as ergonomics, computer science and artificial intelligence. The echoes of this past can be noted in international standards such as ISO 9241-210 “Ergonomics of human-centred system interaction” which describes human centred design as “an approach to systems design and development that aims to make interactive systems more usable by focusing on the use of the system and applying human factors/ergonomics and usability knowledge and techniques”.

Approaches such as those described in ISO 9241-210 address the needs of the users of tools since tools have predetermined functions. The difficulty in the case of driving is that drivers do not always adopt the point of view of a “user” of a “tool”. As Susan Gasson (2003) has highlighted the “user-centred system development methods fail to promote human interests because of a goal-directed focus on the closure of predetermined, technical, problems”. Lucy Suchman (2007) has further suggested that “…the coherence of action is not adequately explained by either cognitive schema or institutionalised social norms. Rather, the organization of situated action is an emergent property of the moment-by-moment interactions between actors, and between actors and the environments of their action.” According to these points of view, and like any other human activity, driving is a process of communicating with the vehicle at any point in time and learning from the interaction with it, thus driving cannot be fully explained by the physical, perceptual and cognitive objectives of vehicle and roadway design.

To a greater extent than ergonomics or human factors, human centred design Giacomin (2012a) is based on techniques which communicate, interact, empathise and stimulate the people involved at every stage of the design process, obtaining an understanding of their needs, desires and experiences which often transcends that which the people themselves actually realised. Practised in its most basic form, human centred design leads to products, systems and services which are physically, perceptually, cognitively and emotionally intuitive. In its more advanced forms, it discovers latent needs and desires, supporting the achievement of desired futures for society.

The most successful examples of 21st century human centred design are probably best described as processes which answer an incremental set of questions regarding the relationships which an artefact either creates or facilitates. Giacomin (2012a) has suggested the framework of the human centred design pyramid (see Figure 1) which is a simple hierarchy which has at its base the scientific facts about human physical, perceptual, cognitive and emotional characteristics, followed by progressively more complex, interactive and sociological considerations. At its apex it contains the metaphysical meaning which individuals form based on contact with the design, and the sociological behaviours that follow from that meaning (Holt and Cameron 2010).

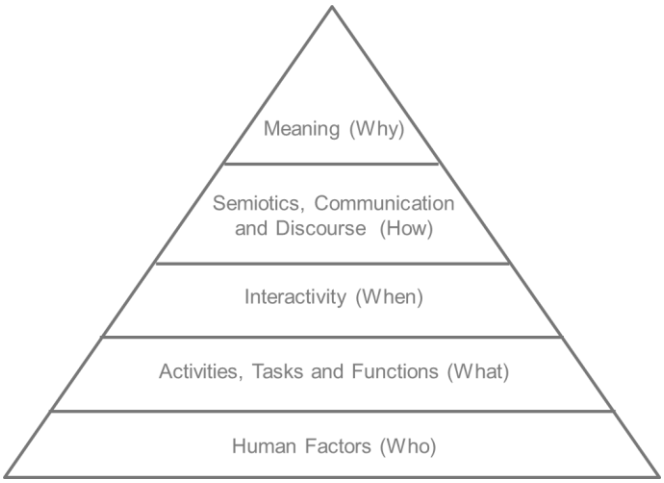

Figure 1) The human centred design pyramid.

The tools used by human centred designers include previously determined scientific facts such as anthropometric, biomechanical, cognitive, emotional, psychophysical, psychological and sociological data and models which provide the boundaries within which to design. Further tools include methodologies for interacting with people in such a manner as to facilitate the detection of current meanings, desires and needs. Finally, when attempting to achieve disruptive innovations rather than incremental innovations, human centred designers deploy methodologies which simulate new opportunities and possible futures for purposes of emersion, reflection and discussion. Table 1 provides a partial list of current human centred design methodologies.

Facts Regarding Humans and Society	**Capture of Meanings and Needs**	**Simulation of Possible Futures**
- Anthropometric data sets and models - Biomechanical data sets and models - Psychophysical data sets and models - Cognitive data sets and models - Emotional data sets and models - Psychological data sets and models - Sociological data sets and models - Philosophical data sets and models	Verbally based - Ethnographic interviews - Questionnaires - Day-in-the-life analysis - Activity analysis - Cognitive task analysis - The five whys - Conceptual landscape - Contextual inquiry - Think aloud analysis - Metaphor elicitation - Be your customer - Customer journey - Personas - Scenarios - Extreme Users Non Verbally based - Game playing - Cultural Probes - Visual journals - Error analysis - Fly-on-the-wall observation - Customer Shadowing - Body language analysis - Facial coding analysis - Physiological measures - Electroencephalograms	- Word concept association - Role playing - Focus groups - Co-design - Experience prototype - Real fictions - Para-functional prototypes

Table 1) Human centred design methodologies.

Human Centred Design and Driving Safety

An important distinction between an ergonomic approach to driving safety and a human centred design approach involves the difference between “human performance” and “human behaviour”. In highly simplified terms, “human performance” refers to what a human can achieve when asked to perform a specific task in a specific manner, while “human behaviour” refers instead to what a human will mostly likely do within the context of an environment when left to interpret the surroundings, choose the priorities, and act in the manner which he or she feels is most appropriate or beneficial. As Caird and Horrey have neatly summarised (Fischer et al. 2011) in reference to the use of driving simulators in research:

“Simulators measure driving performance, what the driver can do. However, safety is determined primarily by driver behaviour or what a driver chooses to do. It is exceedingly unlikely that a driving simulator can provide useful information on a driver’s tendency to speed, drive while intoxicated, run red lights, pay attention to non-driving distinctions, or not fasten a safety belt. Twenty-year-olds perform nearly all tasks on simulators better than the 50-year-olds, but it is the 50-year-old who has sharply lower crash risks.”

While ergonomic or human factors experiments have usually consisted of scientific measurements of "human performance", the majority of the human centred design activities have focused instead on "human behaviour" issues such as the identification of the categories of interaction and the identification of the values and meanings which produce them. A typical example is the recent study by General Motors (Gellatly et al. 2010) which used contextual interviews to identify affinity groups which ended up including the following:

- *My Values Around My Car*
- *Managing My Carried In Devices*
- *Managing My Life's Digital Content*
- *What I Do Besides Drive*
- *Driving With Distractions*
- *Finding My Way*
- *Learning the Controls and Displays*
- *Using the Controls and Displays*

The GM study permitted the company to focus on well-articulated issues which influence the focus of attention, the sources of distraction, the splits in attention and the high level values and concerns. Having identified individual influences on driver behaviour, each affinity group was later developed into a specific product design activity within the company.

In a similar manner, current research performed by the Human Centred Design Institute (HCDI) has identified two concepts which are acting as focal points for current driving safety research. The first and the more phenomenological is that of "naturalness of interaction", while the second is the more cognitive and sociological concept of "emotional safety".

"Naturalness of interaction" can be defined as:

"The degree of intuitiveness and appropriateness which characterises the situated interaction which occurs between intelligent or semi-intelligent creatures, involving the respect of sociological, psychological, psychomotorial, cognitive and perceptual norms and expectations."

In the case of the road vehicles the "naturalness of interaction" has become a focus of human centred design interest in recent years due to the increasing number and complexity of semi-autonomous and autonomous electro-mechanical systems deployed within the vehicles. The growth of vehicle and roadway automation has led to greatly increased complexity of interaction between the driver and the technological systems, with some voice-recognition technologies producing near-human interactions for simple tasks such as the raising or lowering of windows or the control of the infotainment functions.

Research is currently under way to fully articulate the concept of "naturalness of interaction" between the driver and the in-vehicle systems, and to develop a formal framework which considers the specificities of each of the in-vehicle systems (each primary control, each secondary control, each navigation system and each infotainment system). From the point of view of driving safety, the research hypothesis is that the use of vehicle controls which involve a more "natural" mode of interaction with the driver will increase road safety by reducing cognitive loading on the driver and by increasing driver emotional activation and engagement. I.e., divergences from "naturalness of interaction" are expected to lead to slower reaction times, greater mental workload, increased human errors and lower situation awareness when performing classical ergonomic driving tests.

The emotional safety of a given driver-vehicle scenario can instead be defined as:

"The degree of similarity which exists between the emotional states of communicating intelligent or semi-intelligent creatures, involving a correspondence in the holistic overall functional state and preparatory priming of each creature, leading to a reduction in miscommunications and risk."

Emotional safety has become a focus of human centred design interest in recent years due to the deployment within road vehicles of automated operating modes such as "sport" and "economy". These operating modes (Giacomin 2012b) have provided technical system settings which share some

characteristics in common with the basic emotions (Cohan and Allen 2007; Oatley et al. 2006; Van Gorp 2012) which characterise the behaviour of all living creatures. By predisposing the vehicle towards certain global behaviours, the operating modes exhibit emotion-like control over the internal functioning of the individual technical systems and on the externally observable behaviours which they produce.

Research is currently under way to fully articulate the concept of “emotional safety” and to develop a formal framework for evaluating the degree of convergence between the operating mode of the vehicle and the emotional state of the driver. A small number of road vehicles already deploy simple systems which monitor the steering usage, throttle usage, brake pedal usage and other simple parameters which provide a measure of the driver’s emotional state, and which adjust the vehicle operating mode appropriately. Such simple systems provide some degree of emotional safety”, but a framework is required in order to fully develop and extend such systems.

From the point of view of driving safety, the research hypothesis is that a better and more rapid matching of the characteristics of the road vehicle’s operating modes with those of the human driver’s emotional state will increase road safety by reducing miscommunications between the vehicle and the driver, and by maintaining a more pleasant end efficient relationship between the two.

The final frameworks for both “naturalness of interaction” and “emotional safety” are expected to involve a mixture of logical elements which include a-priori physical considerations, a-priori perceptual considerations, a-priori emotional considerations, a-priori social interaction considerations and emergent co-operative constructs. Both are new concepts which have emerged as part of human centred design activity and which currently appear highly interesting due to the growing complexity of modern road vehicles and the increasing degree of interaction and intelligence which they now demonstrate.

Conclusions

A number of observations regarding the nature of ergonomic and human factors activity have been made, and those characteristics have been compared and contrasted with the currently popular design paradigm of human centred design. A distinction has been drawn between “human performance” and “human behaviour”, and the benefits of a more behaviour-based approach to vehicle design and driving safety have been proposed. Two emerging human centred design concepts have been introduced which are called “naturalness of interaction” and “emotional safety”, and a basic definition of each has been provided. Observations were made regarding why the two concepts are emerging as focusses of human centred design research, and regarding what potential benefits their development might bring.

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