Perceptual errors – Application for train driver

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PERCEPTUAL ERRORS – APPLICATION FOR TRAIN DRIVER

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Abstract: The human meaning offers us many interrogations, and particularly the first step in the meaning process: the perception. We take an interest on perceptual errors which deals with our inability to interpret the surrounding information correctly, as suggested by James J. Gibson in his book "The Senses Considered as perceptual Systems". He introduced two meanings of "to sense" which are to detect something and to have a sensation. For example, in the train driving task, the driver can have the sensation to face no restriction but does not detect a stop panel. Perceptual errors are a main issue particularly in train driving task. According to his definition, Gibson developed another concept around the perception: "affordances" or how our environment can suggest managing our task. This point of view seems to be linked with our interest in perceptual errors and some words in this present paper can introduce them better.

Keywords: human meaning, perception, perceptual errors, train driving, affordances.

1. INTRODUCTION

Modelling human behaviour is a complicated task because Human are variable and unpredictable. Human reasoning depends not only on one's own characteristics but also on the environment, the situation and the task to manage. A huge quantity of parameters and variables to categorize all of them can be found. It is impossible to include the whole in a model. Some authors have made some compromises. For example in his famous model (Rasmussen, 1986), Rasmussen included different situations (usual, known, unknown), the level of experience and the level of knowledge of the Human, but excluded critical situations, the Human state characteristics like tiredness or stress level and the task characteristics (workload).

Rasmussen has eliminated the parameters and the variables that he did not need to catch the aim of the model. It is interesting to wonder what the goal of a model is; it depends on the reproduction of the human cognition process or on its description.

Much variability is observed in model designing. It implies that a lot of Human behavioural models can be found and sorted in order to detect the one which is the more relevant for us. One of them can be interesting for us because it introduces perception. It's a matter of the four activities of the Human reasoning mechanism according to (Riera, 1993). These activities are:

- Perception: search, detection, acquisition and information identification,
- Interpretation: information process, problem solving and decision making,
- Actions,
- Communications: asking, answering and verbal exchanges with others, (Berliner and al., 1964).

Some cognitive user models enable to describe, analyze, and predict aspects of user cognition, such as the Interactive Cognitive Subsystem (ICS) (Barnard & Teasdale, 1991). In this model, the cognition is represented as a flow of information between nine subsystems, and the processing performed on this data. Among these subsystems, we can exclude the visual, the acoustic, and the body-state subsystems are responsible for sensory processing.

Another cognitive user model called Executive Process Interactive Control (EPIC) was introduced by Keiras and Meyer (Keiras & Meyer, 1997). Perceptual and motor processes have been implemented in a computer and are presented in Fig. 1.

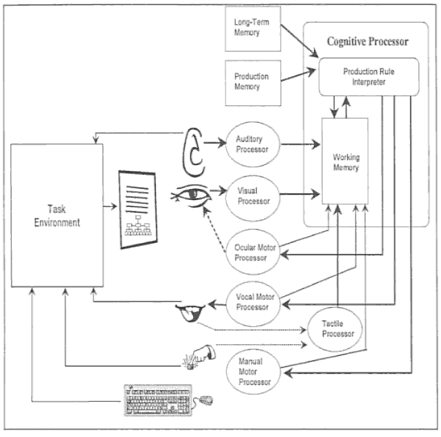

Fig. 1 Overall structure of the EPIC's architecture

The perception, as the first step of the human reasoning mechanism, is a major activity in the human cognition process. However many interrogations are raised about it including the understanding of the perception mechanism by the affordance concept, the causes of perceptual errors and particularly those which occur during train driving or in the kitchen, in order to be studied in some future experiments.

2. PERCEPTION AND AFFORDANCES

Numerous theories focus on the perception. One of the oldest was developed by the Gestalt theorists (Wertheimer, 1923), (Koffka, 1935), (Kohler, 1940), (Kohler & Wallach, 1944). This theory is based on the principle that the excitations on the retina are converted into forms by a process of organization in the brain. This idea of organization implies the building of "law of form" such as universal characteristics describing form-in-general, the idea that above forms is a whole which is different from its parts and the least dynamic.

J. J. Gibson studied this theory and rejected the view of the Gestalt theorist presented by the rules in the top of this chapter, in his article "What is a form?" (Gibson, 1951). According to him, "all form-perception depend on probabilities, inferences and norms – in other words, on subjective factors". The theory of Gibson takes part in behavioural theory of perception and is well-known as the concept of affordance.

An affordance is the quality of an object, or an environment that allows an individual performing an action. According to Gibson in his book "The Theory of Affordances"(1977), affordances are all action possibilities latent in the environment, objectively measurable and independent of the individuality to recognize them, but always in relation to the actor and therefore dependent on their capability. So for him all actions are possible, good actions as well wrong actions. The Norman's theory about affordances conflicts the Gibson's view. For him, the concept is not only dependent on the physical capabilities of the actors, but also on their goals, plans, values, beliefs and past experience. Affordances according to Norman raise the question about the manner for an object to interact with. To summarize they are the action possibilities of which the actor is aware. The two definitions are sometimes antagonist and it is difficult to make preferences for one or for the other. We can take the example of the train driving task to develop this idea.

In train driving, learning the task is a long process and a lot of aptitude tests on the driver are carried out. So the Norman's definition is more closed to the train driving task. For example if warning signal appears in the driver cabin, he knows the process to solve the problem. But if we consider perceptual errors, sometimes the driver is in front of a red signal and according to the rules, he must stop the train. But he does not because he misunderstands and interprets the signal as green. If no action is a kind of all action possibilities then we meet in this example the Gibson's idea. It seems difficult to prefer one definition than the other one.

Another difference between the two theories is their capability to be applied in concrete terms. Norman uses affordances to develop human-machine interaction and particularly the Human-Computer Interaction (HCI) such as he defined them in his book "The Design of Everyday Things" (originally called "The psychology of Everyday Things") in 1988. Moreover, Norman has worked in the computer company Apple and in his document "Affordances and Design" (Norman, 2004), he developed "Four principles for screen interfaces". The Norman's theory can be use in practice.

Concerning Gibson, no building was made by him to apply his ideas in practice. However some researchers tried applying the "Ecological Approach" in some "Ecological Interface Design" (EID) (Vicente, Rasmussen, 1990). EID is a theoretical framework for designing user interfaces for complex socio-technical systems and has been applied to a variety of domains like process control, aviation, and command and control. The framework concerns the design of interfaces assisting in coping with unfamiliar and unanticipated events. Some researchers have developed some method from the Gibson's theory. First the Naturalistic Decision-Making (NDM) which was developed by (Klein, Orasanu, Calderwood & Zsambok, 1993), can be explained by "the way people use their experience to make decisions in field settings" (Zsambok, 1997). The NDM contributes in the development of practical methods based on contextually driven models for improving decision-making effectiveness and reducing error (Gore et *al.*, 2006, Lipshitz et *al.*, 2006). The NDM model was extended to the Recognition-Primed-Decision-Making (RPDM) (Klein, Calderwood & Clinton-Cirocco, 1986). The definition of this model is given by Klein and Zsambok in their book 'Naturalistic Decision making', as the way to "explain how experienced fire ground commanders could use their expertise to identify and carry out a course of action without having to generate analyses of options for purposes of comparisons". This statement is closer to the theory of Gibson.

In the next section, perceptual errors and their consequences are studied.

3. PERCEPTUAL ERROR

A misperception can imply some incidents (Hollnagel, 1998). Hollnagel presented specific cognitive functions as an individual related genotype of an erroneous action, *e.g.* the causes of human errors, and convince us to develop the question in this paper. One of the problems about the perceptual error is the way to detect them because some perceptual errors do not cause observable consequences, except if the error causes an accident. And about the causes, it seems to be hard to catch them. We have ideas thanks to (Gibson, 1966) in his book "The Senses Considered as Perceptual Systems". For him deficiencies of the perceptual process are due to a failure of organ adjustment at high intensity, when registration in memory is impossible and/or when we are face to an exceeded system. He introduces five causes in the origin of these phenomena:

- Pain supplants perception in this event,
- Physiological after effects,
- The obtruding of sensation on perception,

- After-effects of habituation,
- Over-selective attention.

These concepts must be defined clearly to be tested in a next time, so we give some explanation about them in the following part.

Pain is the dictation of avoidance of the injury. It is not a perception activity and gives no information about the world or only about the body of the observer; it creates some interferences with perception process.

An example of physiological after effects is the illusion of the water which feels cold to a warm hand but warm to a cold hand. The illusion is an after-effect of temperature adaptation. The physiological after-effects do not really interfere with the getting information but distract the attention to registering objective facts.

To explain the obtruding of sensation on perception, we must consider some contradictions which can be observed between the three dimensions vision and the two dimensions vision. The reality around us appears in three dimensions and we are used to this, so we expect to see same real shapes every time, everywhere. But when we observed a picture, a drawing, a movie, etc., the aspect is in two dimensions and different on what we expect, so we must make some extrapolation, sometimes good, sometimes wrong. The optical illusion uses this principle.

The after-effects of habituation are illusory negative after-effects due to the adaptation on habituation. When we plunge our hand in warm water, after ten minutes the warm sensation disappears. We build some neutral value of perceptual qualities and when we are face to habituation we can reset these.

The over-selective attention occurs when we get too much information. Some experts think about an economical strategy of perception. Some important information afford by the object can be missed.

Anyone had already experienced misperception and had faced the Gibson's causes of perceptual error. As causes are generic, many domains can be selected to confirm them like train driving and kitchen use. Each one implies perceptual tasks and perceptual errors to be easily captured due to incident consequences. Indeed, if we do not see a wrong selection of the oven button, the preparation can be burnt and if the train moves through a forbidden signal, we can have the view on the control-board.

In the first subsection, perceptual errors in the train driving context are taken into account.

3.1-Perceptual errors in the train driving task

The train driving implies that you have received knowledge to drive according to the law and that you have all physiological capacities to manage it. The process to obtain the driving license is long and difficult to avoid accidents occurrence. Unfortunately, some do. In our goal to understand the Human reasoning, it's interesting to notice that in some cases the driver is responsible for the accident. Particularly, perceptual error can occur during the train driving and cause damages. The heaviest example is the Ladbroke Grove rail crash in 1999, in England. Thirty one people, including the drivers of both trains involved, were killed, and 227 people were admitted to hospital. The analysis conducted by Lord Cullen of the causes of the accident suggests that the restrictive view of signalling, the no-standard shape of the signal SN109 and the bright sun rising shining directly into the signal lenses implied a misperception by the inexperienced train driver in charge of the train driving (Cullen, 2000).

The application of some Human Error Identification technique (HEI) on train drivers is in use by many research teams. The Technique for the Retrospective and Predictive Analysis of Cognitive Errors – rail version (TRACEr-rail) and the Human Factors Analysis and Classification System (HFACS) allow results comparison obtained by these methods (Baysari, and *al.*, 2008).

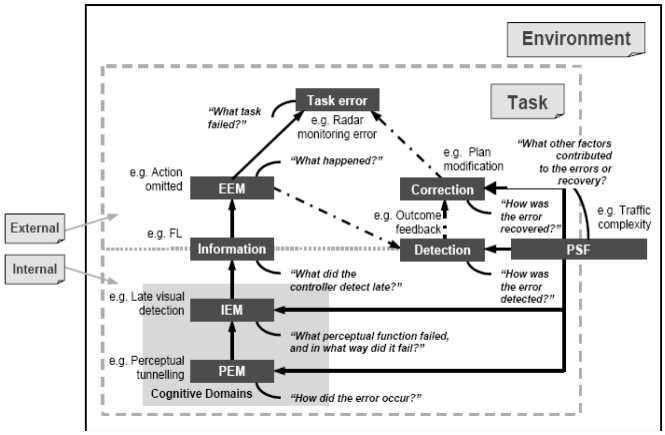

Fig. 2: Relationship between TRACEr classification systems (Shorrock and al., 2002)

The TRACEr method was developed first in response of the issues due to human errors in Air Traffic Control (ATC) with inputs from a variety of activities, including an experimental study, a literature review (covering over 70 sources), the analysis of ATC incidents from 1996 to 1999, interviews of approximately 30 controllers on human error, several large-scale real-time simulations, the use of knowledge elicitation methods, and controller reviews of TRACEr taxonomies. The TRACEr method has a modular structure, comprising eight taxonomies or classification schemes, as shown in **Erreur ! Source du renvoi introuvable.**. Those which concerning the cognitive model include was based on the 'simple model of cognition' (SMoC) (Hollnagel and Cacciabue, 1991):

- Perception: errors in visual detection and visual search, and errors in listening.
- Memory: forgetting (or misrecalling) temporary or longer-term information, forgetting previous actions, and forgetting planned actions.

- Judgment, planning and decision-making: errors in judging aircraft trajectories, errors in making decisions, and errors in planning.
- Action execution: actions or speech performed notas-planned.

In the rail version developed by the Rail Safety & Standard Board (RSSB, 2005), 'violation' was added in the list of taxonomies of the method as shown in **Erreur ! Source du renvoi introuvable.**. The method was also used in Australia from Publicly available railway incident and accident reports spanning the years of 1998–2006 were retrieved from the Australian Transport Safety Bureau (ATSB, 2007), the Office of Transport Safety Investigations (OTSI, 2007), the Victorian Department of Infrastructure (DOI, 2003) and Queensland Transport (QT, 2007).

Table 1. Retrospective TRACERr taxonomy (RSSB, 2005)

Taxonomy	Description
Task errors	Describes error in terms of the task that was not performed satisfactorily
Cognitive domains	Describes the process within which the error occurs: perception, memory, decision, action and violation
Internal error modes (IEM)	Describes what cognitive function failed or could fail and in what way
Psychological error mechanisms (PEM)	Describes the psychological nature of the IEMs, the cognitive biases that are known to affect performance
Information	Describes the subject matter or topic of the error
Error detection	Classifies how the driver error was detected, how the error was relayed to the driver and what factors influenced the detection of the error
Error recovery	Classifies how the error was recovered and what factors influenced the recovery of the error
Performance factors (PF)	Classifies factors that have influenced or could influence performance, aggravating the occurrence of errors or assisting error recovery

The TRACEr-rail analysis indicated that most 'train driving errors' were 'violations' while most 'train stopping errors' were 'errors of perception', as shown in **Erreur ! Source du renvoi introuvable.**.

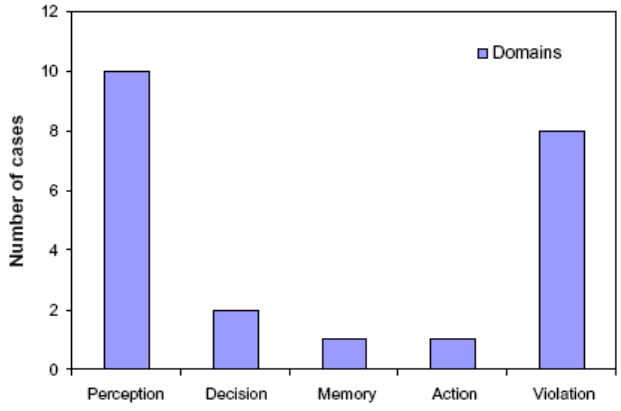

Fig. 2: Number of errors belonging to each TRACEr 'Cognitive Domain' category.

So, according to the TRACEr method, train cabin is a good place to study perceptual errors.

The HFACS method was first developed in the context of aviation and is based on Reason's model of human error (Reason, 1997). In his model, often referred to as the "Swiss Cheese Model", he included three system levels: unsafe acts, local workplace factors and organizational factors in Fig. 4.

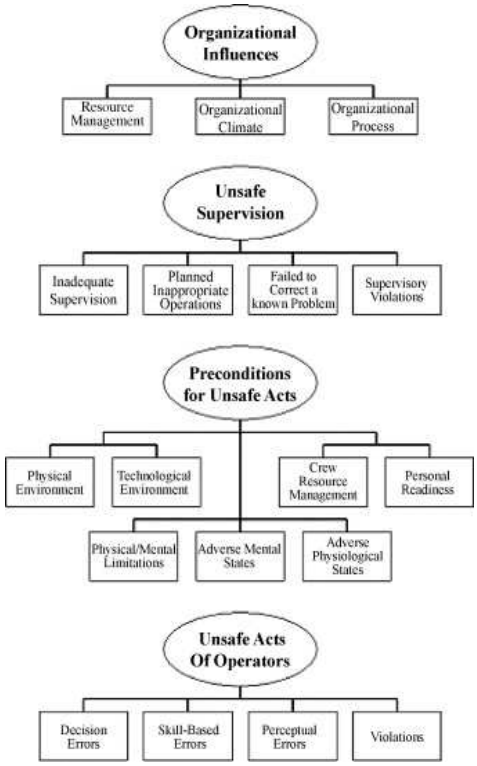

Fig. 4 The HFACS framework. Each upper level is proposed to affect items at the lower levels (Wiegmann and Shappell, 2003).

The result obtained from the same Australian train accident reports than with TRACEr-rail with the HFACS method shows that slips of attention (*i.e.* 'skilled based errors') were the most common 'unsafe acts' committed by drivers. The result is different, in Fig. 5, than the one obtained with the TRACEr-rail method.

The result is different than the one obtained with the TRACEr-rail method.

Fig. 5: Number of errors belonging to each HFACS 'Unsafe Acts' category.

The origin of this difference could be due to the definitions of perceptual errors. According to (Wiegmann & Shappel, 2001) in the HFACS applied on aviation, perceptual errors occur

when sensory input is degraded or 'unusual'. They explain this by examples such as "at night driving". For the TRACEr-rail, perception errors are as we have noticed previously, errors in visual detection and visual search, and errors in listening. The second definition is less limited than the previous one. That can explain that the perception errors are more common with the TRACEr-rail method; Moreover, this definition is closer that the one that we have chosen. Indeed, it includes search, detection, acquisition and information identification as (Riera, 1993) suggested it.

To conclude, we can think that train cabin is a great place to study the perceptual errors such as we have defined them. Studying perceptual errors in the train driver cabin must be the good way to test the Gibson's causes and think about the manner to use affordances to reduce them.

In the second subsection, another way to study perceptual errors in the kitchen domain is envisaged.

3.2-Perceptual errors in common life: In the kitchen

Each time in our life we are confronted to this kind of perceptual issues, in particular in the kitchen. It constitutes an optimal place to capture perceptual errors. Indeed in kitchen, all of our senses are appealed (view, smell, hearing), that means that many perceptual activities occur in this place. Moreover in many cases kitchen perception errors cause directly an observable consequence, such as an over-cooked meal. We can study them easily. As for the train driving task, it would be interesting to ask ourselves about the causes of perceptual error and confront them with these developed by Gibson. This study can show us how many are the perception errors in the kitchen.

As a common place for everyone, kitchen is also an interesting place to study affordances. Unexpected situations can occur with the overflow of a pan full of water or the cooking duration of a chicken, and it cannot be said that people are trained to avoid some of them as the number of domestic accidents proves it. According to a study carried out in 1997, the French national institute of healthcare and medical research (INSERM) has shown that accidents in the kitchen caused twice more deaths than in road domain. We are closed to the affordance definition of Gibson, who links perception as a behavioural task. It would be interesting to study affordance in practice in a place such as the kitchen.

Giving the characteristics of the kitchen affordances might allow finding a way to improve interaction between Human and the tools in the kitchen and will be the subject of a future project in collaboration with the French household appliance supplier Groupe SEB.

4. CONCLUSION

Our scope of perception conducts us through perceptual errors and affordances concepts. We have highlighted two places to study them, first the train driver cabin and then the kitchen because perception is in the centre of these tasks and many problems due to a misperception occur in these places.

Some questions are raised throughout the document about the causes of the misperception, about the definition of affordances and then about the solution to improve perceptual activity from the affordances knowledge. The affordances such as Gibson defined them are too theoretical to be applied directly in the practice. However some researchers have produces some models to resolve this problem such as the "Ecological interface design" (EID) (Vicente, Rasmussen, 1990), the Naturalistic Decision-Making (NDM) (Klein, Orasanu, Calderwood & Zsambok, 1993) and the Recognition-Primed-Decision-Making (RPDM) (Klein, Calderwood & Clinton-Cirocco, 1986). Another way to study affordance is to use the Norman's work on the Human-Computer Interactions (HCI) (Norman, 1988) which is less linked to the Gibson's theory.

It would be interesting to compare these different methods before using them according to their theory base, the reliability of their results and the feasibility of their application in different domains. But we can already say that they represent a great tool to implement affordance such as Human-Machine interface and can be used as a index of human perceptual errors.

Our future aim would be to introduce them in the train cabin driver and in the kitchen to obtain answers to our issue which is perceptual error. We expect moreover the possibility to improve the interface between Human and their environment, particularly in the kitchen, by using affordances via these methods.

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