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Presence, Behavioural Realism and Performances in Driving Simulation

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Abstract: Driving simulators are increasingly integrated into the training process by driving schools, but doubts still exist concerning the face validity of such tools, in particular concerning accident prevention. To get some enlighten on the usefulness of this training method we investigate which factors are correlated with driving accidents in virtual training. The factors we decide to consider are: 1) the excessive speed, 2) the violation of safety distance 3) the incapability to predict other drivers' behaviour and 4) the perceived "feeling of presence" that often influences the performances in virtual tasks. The results of our study involving 36 participants pointed out that no statistically significant correlation can be established between any of these factors and the number of cars' accidents during the virtual driving task.

Keywords: virtual reality, driving simulation, presence, autonomous behaviour, user experience, performance evaluation.

1. INTRODUCTION

In the last years driving simulators, which previously were mostly used for research, start to be used as a training tool by driving schools. The increasing adoption of driving simulators is connected with the various advantages of using such technology and in particular with the possibility of experiencing a potentially dangerous situation in a safe way (Winter et al. 2012).

This notion of "safe-danger" represents one of the advantages of simulators but it could as well limit their validity as training tools. As Käppler (Käppler 1993) pointed out, the lack of a real danger in the driving simulators can induce a false sense of safety and push the user to adopt more risky behaviours. This phenomenon influences the "face validity", defined as "the user perception of how realistic an experimental environment appears" (Diels et al. 2015), of the virtual environment. When talking about simulations the concept of face validity is strictly connected with the one of "presence" defined as "the authentic feeling of existing in a world that is different from the physical one in which our body actually is" (Bouvier 2009).

2. PRESENCE AND BEHAVIOURAL REALISM IN DRIVING SIMULATIONS

Presence is probably one of the most popular concepts in virtual reality's research and the correlations between presence and performances in virtual tasks have been studied by various researchers like Slater (Slater et al. 1996), Welch (Welch 1999), Youngblut (Youngblut & Huie 2003) , Nash (Nash et al. 2000), and Lee (Ai-Lim Lee et al. 2010). Presence is influenced by multiple factors including the realism of the media used to create the virtual environment. It is important to notice that a better quality of the media did not imply systematically a greater feeling of presence. The increased visual realism of the 3d objects, in fact, induces the user to raise his expectation concerning all the others aspects of the simulation. Therefore, to avoid a break in the feeling of presence, an increased visual realism that fools our perception must be followed by an equivalent increased behavioural realism to fool our cognition.

The importance of implementing realistic behaviours is particularly challenging when talking about human behaviour. This is mostly due to two reasons. The first is that humans are particularly sensitive to detect any abnormality in human behaviour. The second is that human behaviour is often complex and unpredictable. As the studies in the field of analysis of activity have shown, even in very structured settings, there is a clear difference between what humans are supposed to do (the prescribed task) and what they actually do (the realized task) (Sanders 2006). Humans do not merely obey to a set of rules, but they adapt their behaviour in accordance with their goals and their interpretation of the situation. As a result, algorithms able to reproduce human behaviour are difficult to model in the frame of classical computer science (that historically adopts a sequential and deterministic approach).

Driving simulations are a good example of the balance between prescribed task and the actual behaviour. On one side, we have a set of explicit norms (the rules of the driving code) that are formally written and easy to implement. On the other side, we have the user that, according to his internal motivations, like his urge to arrive on time, adapt (more than adopt) those norms. The rules of the driving code have to coexist with the set of habits and social norms that influence the driver's actual behaviour. As a consequence, taking in care just the rules of the driving code, without considering the

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other elements, will generate a driving behaviour that, even if formally correct, will look unnatural.

3. EVALUATION OF DRIVING SIMULATOR.

The evaluation of virtual reality simulators is a complex task that varies in accordance with the characteristics and the purposes of the simulators to evaluate. With the increasing adoption in the driving schools of driving simulators, it is legitimate to inquire the role of these simulators in the prevention of driving accidents.

Driving accidents are one of the main causes of accidental death in the world. According to the World Health Organization (World Health Organization 2015), there were 1.25 million road traffic deaths globally in 2013. Car accidents are often caused by multiples factors including fatigue, distraction or alcohol and drugs assumption. According to the American National Centre for Statistics and Analysis (National Center for Statistics and Analysis 2013), excessive speed is involved in almost the 20% of fatal crashes in 2013 while the British Department of Transport (British Department for Transport 2015) estimate that the 23% of driving accidents are due to “Failure to judge other person’s path or speed”.

For our evaluation, we investigate which factors are correlated with accidents during a driving simulation. We decide to focus on four factors: three of them are connected with real life driving accidents and are: 1) the excessive speed, 2) the violation of safety distance and 3) the incapacity to predict other drivers’ behaviour. The fourth factor that we consider is the perceived “feeling of presence” that, as previously stated, could influence the performances in virtual tasks.

What we expect is to find a positive correlation bounding the number of violations (both of the speed limits and the security distance) to the number of accidents. Concerning the ability to anticipate the other drivers’ behaviours and the “feeling of presence”, we expect to find a negative correlation with the number of accidents.

3.1 Measuring driving accidents, violation of speed limits and violation of security distance.

In our experiment, the simulator automatically computes the number of accidents, the violations of the speed limits and the violation of the security distances.

A driving accident is defined as a collision between the car driven by the participant and any obstacle (cars, pedestrians, guardrails, walls) present in the virtual environment. When a collision is detected, independently by the intensity of the crash, the simulation is paused and an accident is counted.

Violations of speed limits are computed as the number of seconds in which the speed of the car is higher than the speed indicated by the speed signs present in the environment. The driving exercise takes place in an urban environment with the speed limit set at 50km/h in accordance with French driving code.

Violations of the distance of security are measured as the time in seconds that the participant’s car is too close to the car in front of him. In accordance with the French driving code, the security distance is defined as the distance that the driver covers in 2 seconds at his actual speed. For instance, driving at 50km/h, a violation of the security distance is counted when the distance between the two cars is less than 28 meters.

3.2 Assessing the feeling of presence.

To measure the feeling of presence in our experiment we adopted the French version of the IPQ presence questionnaire (Schubert & Friedmann 2001).

The IPQ is a likert scale’s questionnaire constituted of 14 items to be evaluated on a seven values scale, ranging from -3 (fully disagree) to +3 (fully agree). The 14 questions are connected to four underlying constructs related to the concept of presence.

The four constructs are:

•GP = General Presence (i.e. Sense of being in a place).
•INV = Involvement (i.e. Captivated by the virtual environment).
•SP = Spatial Presence (i.e. Felt present in the virtual place).
•REAL = Experienced Realism (i.e. How real seemed the virtual environment in comparison with the real world).

3.3 Assessing the ability to predict the behaviour of the others.

To assess the correlations between the number of accidents and the ability of the user to predict the behaviour of the other cars, we decide to adopt the construct “Predictability of behaviour” of the “Autonomous Behaviour Questionnaire” that we recently developed.

Our questionnaire is based on a likert scale with seven values ranging from -3 to +3. The anchors of the questionnaire are the following: +3 that stands for “I totally agree with the sentence” and -3 that stands for “I totally disagree with the sentence”.

To develop our questionnaire, we adopted a two-stage approach similar to the one proposed by Vallerand (Vallerand 1989). In this approach, the first stage, which consists in the identification of the items of the questionnaire, is followed by a factor analysis to retain the most relevant items.

The identification of the items is based on a pilot study where 9 volunteers, after 15 minutes of experience with the driving simulator, were questioned about their feelings in a self-confrontation interview. The interview served as base for the content analysis performed in accordance with the “Grounded Theory” (Strauss & Corbin 1990). This analysis identified the 37 items of the questionnaire that the 148 volunteers fulfilled after experiencing the driving simulator for 20 minutes.

To verify the validity of our dataset we performed the following tests. To assess the legitimacy of the number of the participants we computed the “subjects/factors” ratio that