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Research project

"RISK PERCEPTION AND VIRTUAL REALITY"

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Abstract

The research project aims at investigating risk perception in virtual environments. By simulating risks and hazards in high-immersive virtual environments (HIVE), we intend to detect which types of communication convey better information and trigger the appropriate heuristics to perceive risks correctly. We also plan to define a method to enhance the management of risk in low-immersive virtual environments (LIVE). The weaker sense of presence experienced in LIVE enables individuals to adjust the heuristics adopted in real settings, to refine risk perception and to improve skills for managing stressful and traumatic situations. The project intends to provide evidence that virtual reality can be a useful tool to analyze risk misperceptions and to improve mental readiness in choices under risk.

INTRODUCTION

A key assumption on how people perceive risk and take decisions in risky settings, such as insurance and financial markets, is that information processing is generally affected by a number of cognitive biases. The criticisms addressed by Kahneman and Tversky's (1981) heuristic approach and by Slovic's (2000) psychometric paradigm to revealed preference theory, according to which individuals are rational in processing valuable information in decision-making, inform recent empirical research.

A first result is that individuals are generally myopic in assessing risks. They tend to be over-concerned with minor risks having an immediate impact on their daily life, while practically neglect the long-term effects of unfamiliar risks. This attitude explains why non experts tend to rank certain risks as more severe than did experts and to overestimate the magnitude of the same risks. Slovic (1987) identifies two sources of lay people's risk misperception: the degree to which risk is dread, defined as the combination of having a catastrophic potential, perceived lack of control, the unequal distribution of risks and benefits, and the degree to which it is unknown, that is the condition of being unobservable, novel, and with a long latency period.

Another well known fact is that individuals perceive benefits and costs associated to risky events as negatively correlated, which is in contrast with empirical evidence. If individuals exhibit a positive attitude to a risky prospect, they overvalue the associated benefits while under-assess the associated costs. Similarly, when their attitude is negative, the related costs are systematically overvalued.

Finally, it is generally acknowledged that reactions to risks are triggered emotionally and not determined by rational scrutiny. The concept of somatic marker proposed by Damasio (1994) suppose the existence of automatic and unaware affective reactions, discerning what is risky or not independently on the careful weighing of pros and cons.

These stylized facts are supported by a remarkable amount of laboratory and field evidence, which explains the growing people's awareness of limitations in risk perception. As a consequence, economists have proposed policies of *libertarian paternalism* (see Thaler and Sunstein 2008) and citizens have been increasingly relying on the opinions of experts and scientific communities to assess the impact of complex risky events (Fischhoff 2010). At the

same time, the aversion towards manipulative policies and the consideration that experts' judgment is also affected by cognitive biases (overconfidence, anchoring, etc.) prompt different reactions. An example is given by the popularity in the web community of the so-called user-generated content (UGC), provided by non expert users with the purpose of providing information that is valuable for the general audience.

A key element for explaining risk misperception is that risk assessment is negatively affected by the fact that individuals are increasingly exposed only impersonally to uncertain events. When people have indirect experience of risks, they rely on media content (TV, radio, web) to assess the size and the impact of such events. For example, to understand if a certain illness may affect life or if the use of a new device may provoke physical or psychological damages, individuals rely upon TV news. Moreover, people are more and more exposed to information on unfamiliar risks coming from remote areas of the world. Kuran and Sunstein (1999) define "availability cascade" the self-reinforcing process through which media and word-of-mouth cause chain reactions amplifying the collective perception of unknown and remote risks.

These elements are modifying the way people perceive and manage risky environments and require a revision of the research methodology used to evaluate and prevent risks.

1. VIRTUAL REALITY

Virtual reality is a powerful tool to simulate events and tasks by allowing an accurate control of the setting experienced by the decision-maker. This technique can be usefully applied to the investigation of risk perception and management.

Virtual reality is a computer-generated real-time environment where users act in a simulated situation. In practical terms, it is a technical system composed by hardware and software, which generate artificial environments through an interface which stimulates one or more of individual senses. The digitally generated space is such that users' movements are tracked and environs are displayed to users' senses in conformity with their actions. In this setting, events take place in real time and users are immersed in the simulated experience.

This implies that the stimuli from virtual reality dominate users' perception and cognition, although they are typically active and cognitively engaged during the exposure.

The key feature of virtual reality is that the subject being immerse in a virtual representation of reality experiences different sensations from real life. In real world, individuals' perception is biased by their subjective perspectives or personal interests. By experiencing the virtual representation of the same event or environment, these biases can be altered or manipulated.

The concept of layers of reality can be useful to provide insight into this issue. If two individuals observe an item, they may describe it differently depending on their personal involvement. Each perspective corresponds to a different layer of reality. If we take a picture or record on a video of the same item and then digitalize it in 2D or 3D by creating a virtual representation, we offer a third perspective that is common to both individuals. While each individual has his or her own representation of real events, virtual reality can syncretise the different perspectives.

This argument can be rephrased as follows. Virtual reality is opposed to real life because it applies a sort of "filter" to the contradictions due to the conflict of individual perspectives. As a consequence, it is not important to bridge the gap between reality and virtual reality, but rather to select what information in virtual reality is important for scientific or practical purpose. This implies that the detail and the realism of virtual representation are not essential. Virtual reality should not be necessarily the digital replica of real world. When individuals observe a digital representation of an object it could be said that they "anchor" that object, which is perceived in real life according to multiple perspectives, to simulated reality. This process relates a multiplicity of objects to a single artificial representation, which becomes the unique identifier by providing a selection of its salient features. In this way, it is not a faithful copy of our perception of reality but rather a different way to perceive a greater reality that may be also immaterial. This implies that observer's perception may be also altered by introducing in virtual reality elements neglected by senses. This effect can be obtained by two methods, by framing or by naturalistic cue. Framing consists of creating an environment that may be suggestive to subjects as to how to behave. In this way, some elements of real life can be made more salient than others. The decisions taken in the framed environment can be attributed relatively more to the effect of the selected elements. On the

contrary, the provision of naturalistic cues is given by building a virtual environment as close to the real environment taken as reference. By recalling the concept of layers of reality, in this case to create virtual representations of reality is to choose which layers of reality is appropriate to consider.

In short, the technical set-up of virtual reality affords detailed control of the simulated environment in which individual users process information, decide and interact. The plasticity of virtual reality allows to detect and to handle various problems:

- the problem of information overload by making users' attention focused on a subset of factors,
- the saliency of external factors otherwise neglected,
- the assessment of the effect of cognitive biases,
- the lack of awareness,
- the temporal latency of the consequences of present choices;

Finally, virtual reality allows simulating social interaction by creating virtual words that are networked, computer-simulated environments, in which human participants interact by means of virtual identities called avatar. A virtual world may reproduce realistic features of the physical world or be simply fictional, but in both cases users can communicate, interact and make exchanges among them. In this respect, social cognitive theory (Bandura 1977, 2001) argues that a model demonstrating a behavior can have the effect to encourage the same behavior in the observer. Identification refers to the extent to which an individual relates to the model and feels that he is similar to the model. It has been shown that identification increases the likelihood of performing learned behaviors (Bandura 2001; Bandura and Huston 1961) and that individuals need not experience rewards or punishments to learn a behavior to be encouraged (Bandura, Ross and Ross 1963). For example, Fox and Bailenson (2009) provide evidence that virtual self-models can be effective instigators of positive health behavior change. According to this view, virtual reality can be useful to communicate norms and prescriptions, to provide therapeutic treatments and to practice skills in order to improve them. This effect named *vicarious reinforcement* represents another powerful tool for the analysis and management of risk perception.

2. RESEARCH PROJECT

The standard approach in economics to elicit individuals' risk attitude in the laboratory is by submitting them choices over lotteries. The collected evidence shows that risk perception is characterized by marked heterogeneity, within and across individuals, and depends on the kind of tasks and frames faced by the decision-maker. These findings have progressively changed the focus of research on risk assessment from detecting deficiencies and errors in judgment to the understanding of how individuals collect and process information by incorporating insights from evolutionary biology, cognitive sciences and neurosciences.

It is generally acknowledged that decision making is dependent on the cognitive constraints of the decision-maker. In order to predict, describe and explain choices, it is necessary to assess carefully the process of individual learning, to consider explicitly the decision environment and to analyze how decisions depend on naturally occurring cues, such as contextual features, pattern recognitions, and template decision rules. This approach is known as "ecological rationality" (Smith 2003) or "fast and frugal heuristics" (Gigerenzer 2001), which assume that rationality is the consequence of individuals' adaptation to specific decision environments in order to enhance their ecological fitness. As a consequence, cognitive processes are efficient only in relation to a specific settings but they may be inappropriate in other situations.

To provide insight, the research project intends to perform virtual experiments, in which subjects perform their activity within a computer simulation with details, frames and cues provided and controlled by the experimenter. Moreover, behavioral findings can be supplemented by information provided by other research devices, such as functional magnetic resonance imaging (fMRI) to measure brain activity, eye-tracking systems to record gaze direction, and measurement of the evoked skin conductance response to detect affective activation.

Fiore et al. (2009: 69) argue that "VR environment can be used to generate cues that are sufficiently natural and familiar that decisions will be significantly more like those that would be generated in the field with sufficient expertise." Our project originates from a slightly different assumption. Virtual environments can be applied to study the effect of

generating cues neglected by individuals in decision tasks that are perceived as common or familiar. In these situations, people often resort to heuristics or rules of thumb to reduce task complexity and to better manage stress. The project aims at investigating how virtual simulations can be applied to detect and investigate these automatic reactions.

To this purpose, we should first manage the problem of scenario rejection. To study counterfactuals arguments, the experimenter may model environments that are inappropriate, imprecisely or not consistent with subjects' perceptions. In this case, subjects consider the simulation proposed as not realistic and reject the validity of the simulation. To deal with this problem, we will video record subjects while they act in these contexts in order to design virtual simulations which provide them familiar stimuli. This technique also enhances the sense of presence in the user. In virtual experiments, the feeling of "being here" is crucial and depend on two factors: the spatial realism of the environment and the fidelity of the interaction between the user and the virtual world. The former may be obtained by introducing virtual agents moving and communicating each others. The sense of presence can be augmented further by introducing contextual elements and combining appropriate auditory and visual cues that increase users' familiarity with the virtual environment.

Once individuals experience a strong sense of presence, it can be assumed that they tend to replicate automatic reactions usually triggered in real life in similar situations. This happens, for example, in Grigorivici (2003) who analyses the persuasiveness of advertising messages provided in immersive virtual environments. By conveying the feeling of being here, observers experience more arousal and affect, become less aware of the embedded message and tend to adopt the heuristically driven behavior induced by the messages.

Our project intend to apply the virtual reality technology to two different types of environments. The first are defined "desktop or low-immersive virtual environments" (LIVE) and uses computer screen based applications of virtual reality, such as Second Life or World of Warcraft (Banbridge 2007). The second are "high immersive virtual environments" (HIVE), which utilize specialized displays such as CAVE, Head-Mounted Displays, Immersadesk or Augmented Reality (Fox et al. 2009). While LIVE environments are associated to a weaker immersive sense of presence, in HIVE users' senses are dominated by the technical equipment, such as a binocular head-mounted display (see figure 1), including an helmet or headpiece with LCD screens affixed in front of the eyes or a four, five or six-

sided CAVE (computer-assisted virtual environment, see figure 2), that is an enclosed box in which the user is shown images on the multiple interior screens.

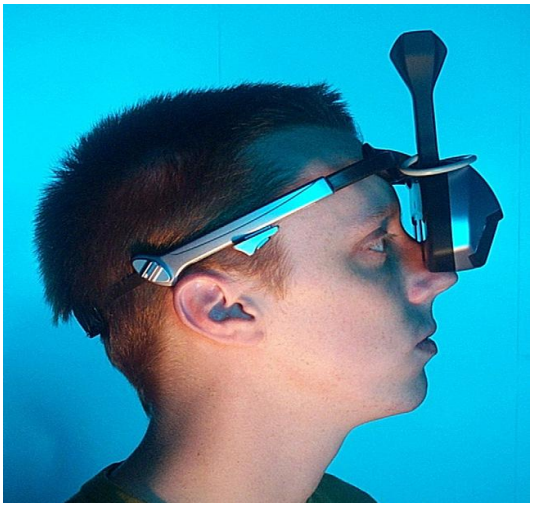

Fig. 1 Head-mounted display.

Fig. 2 A domescreen.

These two technical settings will be utilized to investigate two different features of the processes of risk perception.

PART 1. HIGH-IMMERSIVE VIRTUAL REALITY TO DETECT HEURISTICS AND RISK MISPERCEPTIONS

The first part of the research project aims at investigating risk perception in a high-immersive virtual environment (HIVE). By replicating risks and hazards in a HIVE setting we will detect which types of information (media, writings, slogans) convey better information and trigger the appropriate heuristics to perceive risks correctly. In this part, we will create virtual simulations to make people absorbed by the digitally created virtual environment as to exclude external and uncontrolled cues. This identification allows detecting which reactions to risks are triggered emotionally. In this way, we will obtain laboratory evidence of how individuals react automatically in risky tasks and how risk misperceptions are formed.

PART 2. LOW-IMMERSIVE VIRTUAL ENVIRONMENTS TO CORRECT AND MANAGE CORRECT RISK MISPERCEPTIONS

The second part of the research project intends to envisage a method to alter risk misperception in a low-immersive virtual environment (LIVE). The weaker sense of presence experienced in LIVE enables individuals to adjust the heuristics adopted in real settings, to modify risk perception and to improve skills for managing stressful and traumatic situations. Virtual reality in this case is intended to enhance their mental readiness to correct risk misperceptions.