Experimental Economics in Virtual Reality

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Oculus and Co. will establish a new experimental method in economic research

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Abstract: Experimental economics uses controlled and incentivized lab and field experiments to learn about economic behavior. By means of three examples, we illustrate how experiments conducted in immersive virtual environments can benefit (experimental) economic research.

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Recent developments in virtual reality (VR) technology have the potential to revolutionize the way economists do experimental research. With Oculus' light and affordable head mounted display (HMD) human subjects can literally move and use objects in virtual spaces and interact with others. This technology as well as surround-screen projection systems like CAVEs (Cruz-Neira et al., 1993), allow the experimenter to observe economically relevant behavior and social interaction in a highly immersive and at the same time tightly controlled virtual environment.

Previous applications of VR in (experimental) economics were mainly limited to research in *low immersive* virtual worlds, e.g. Second Life (see e.g., Chesney et al., 2009; Füllbrunn et al., 2011), where *immersion*, i.e., the feeling of "being there", is perceived only indirectly through mouse-controlled avatars, i.e., virtual representations of human subjects. While virtual worlds have some remarkable research potential (Bainbridge, 2007), they also have very important drawbacks for experimental research, e.g., the loss of control over subjects' characteristics (Duffy, 2011). This led economists only recently to begin utilizing controlled virtual world experiments (Twieg & McCabe, 2014).

Blascovich et al. (2002) suggested the use of *immersive virtual environments* (IVEs) as a methodological tool in (social) psychology. They, together with others, discovered that humans indeed perceive *highly* IVEs as "real". This phenomenon is referred to as *presence* (Slater et al., 1994). Due to high costs, however, for a decade, social science research using VR was limited to few labs and small sample sizes. Recently, affordable HMDs and other periphery devices accelerated research in social sciences, such as social psychology to study social evaluation situations (Schmid et al., 2013), in clinical psychology for treatment of social disorders (Falconer et al., 2014), or in linguistics for understanding the role of gestures in human communication (Staum Casasanto et al., 2010).

More than other disciplines, economics focuses on the evaluation of counterfactual scenarios which help to analyze strategic decisions and their efficiency effects. Counterfactuals, however, are not easily observable, not even in field experiments. On the other hand, counterfactual scenarios in the conventional lab settings are often perceived as "sterile environments" since they are not embedded in a natural frame (Harrison & List, 2004). Experiments in highly IVEs could fill a gap by enabling us to test counterfactuals in an exactly controlled but more realistic setup. One could also test settings that would be very costly or simply impossible to implement in the field, e.g., due to physical restrictions or ethical reasons. In the next paragraphs, by means of three examples, we illustrate how experiments in highly IVEs can add value to experimental economics and benefit economic research.

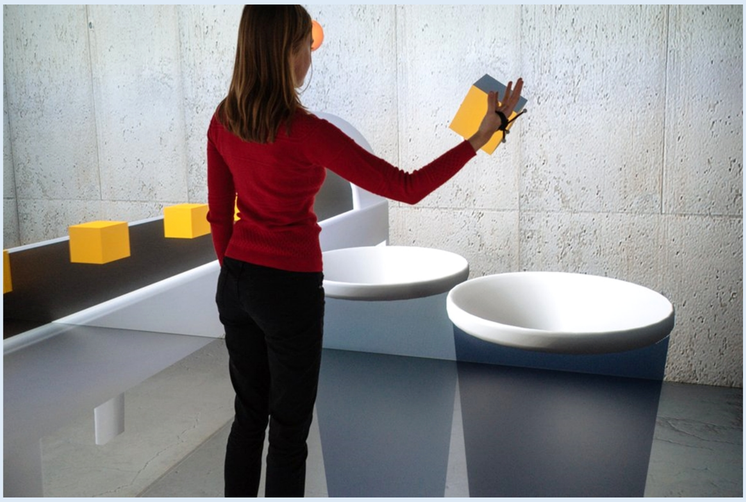
Naturalistic representation: Eliciting (risk) preferences

Preferences expressed and economic decisions taken by human subjects can depend on perceptions of the external context and environment in which a decision problem is presented. A subject who experiences "physical" presence in VR may automatically suppress that she is participating in an experiment displaying a more "natural" behavior. Economists have used the passive observation of 3D modeled wildfires on monitors to evaluate subjects' perception of risks, and driving simulators to elicit risk preferences. By applying a low IVE to a context of evaluation choices, they combine "the strengths of the artefactual controls of laboratory experiments with the naturalistic domain of field experiments or direct field studies" (Fiore et al., 2013). These advantages are very likely to be more pronounced in highly IVEs (cf. Cummings & Bailenson, 2015).

Tracking & realistic interactive tasks: Breaking the limits of real effort experiments in the lab

VR labs allow subjects to perform more natural tasks than in traditional labs where this is confined to a 2D computer screen. Furthermore, *tracking* in VR enables measuring a subject's position, orientation, and movements in space. In a current study conducted in the CAVE of the RWTH Aachen University, we capture exact measures of subject's effort not in only one but in several dimensions (Gürerk et al., 2014). In our setup, the subject is inside a virtual production hall. There, she physically works at a virtual conveyor belt sorting out virtual cubes with a defect. To check for defects, the subject can literally grasp and rotate the cubes. We are able to measure performance multidimensionally by taking the number of not rejected cubes with various types of defects, the number of rejected cubes without defects, the number of grasps and the duration of grasps into account. We can evaluate how subjects make the trade-off between quantity and quality as a function of the economic incentives provided. Other dimensions of tracking such as precision of grasps, body movement and eye tracking can also be included.

Panel a: aixCAVE



Panel b: HMD

Figure 1: Panel a: Subject interacting with a virtual cube in the aixCAVE of the RWTH Aachen University. Panel b: Person with HMD grasping a virtual object.

The magic of *co-presence*: Solving the reflection puzzle through human-avatar interaction

Using virtual humans in social interactions (Schroeder, 2011) creates the opportunity to analyze causal relationships between simultaneously observed individuals' (or groups') behavior, which in traditional experiments is severely hampered due to the well-known reflection problem (Manski, 1993). In the setup explained in the section before, we introduce a virtual co-worker, i.e., a computer-controlled avatar who works at a parallel conveyor belt and is observable by the human subject (Gürerk et al., 2015). The virtual co-worker exhibits different working behavior from slow to fast or precise to careless, respectively. Since the human subject cannot influence the virtual co-worker, we can rule out the identification problem. This enables us to observe non-confounded peer effects of the avatars' work speed and work care on the human subject's performance. As a further related idea, physically or behaviorally pre-programmed avatars may help overcome cultural barriers when conducting experiments with participants coming from different parts of the world.

Figure 2: Subject working in the aixCAVE of the RWTH Aachen University in the presence of a virtual co-worker.

Challenges

The main challenge in conducting experimental research within IVEs is the trade-off between costs and internal as well as external validity. Using more costly VR systems like a CAVE instead of a low-cost HMD usually increases the immersion, as subjects can perceive their complete (physical) body, especially their interacting hands. Furthermore, an avatar's realistic visualization and movements crucially affect its acceptance by the subjects. Modeling natural interaction patterns of avatars used to be a fundamental technological issue, but recent developments in optical tracking technology brought improvements with affordable prices.

Conclusion

Currently, experts as Jaron Lanier or entrepreneurs as Mark Zuckerberg expect a great future for VR in entertainment as well as in transforming human communication and collaboration in shared virtual spaces, e.g., virtual shopping or doctor visits. We believe the new possibilities have also great potential to take experimenting in economics to the next level, by enabling us to elicit preferences more reliably, by leading to a better understanding of the relation between incentives and effort, and by the investigation of economic (and social) interactions in a way never possible before.

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Appendix

Project Profiles

Experimental Economics in VR, School of Business and Economics, RWTH Aachen University

Experimental Economics in VR is one of the key projects of the “Business & Behavioral Metrics Lab” of the “Interdisciplinary Management Factory” at the School of Business and Economics. The Business & Behavioral Metrics Lab, founded in 2012, aims at the development of a series of techniques for a radically new concept in experimental economic research. The idea is to analyze and quantify individual behavior in organizations and markets that is supported with new technological measuring methods, e.g., virtual reality experiments, under controlled laboratory conditions. Different work environments in organizations will be replicated as realistically as possible through collaboration with other disciplines and their technical expertise. More information about the project “Experimental Economics in VR”: http://www.expecon.rwth-aachen.de/go/id/ffma/

Virtual Reality Group, IT Center, RWTH Aachen University

Since its inception in 1998, the VR Group has focused on two aspects: to conduct application-oriented research in and provide access to methodology from the fields of virtual reality, human computer interaction, and immersive visualization. The VR Group operates one the largest VR labs in the world. Equipment and facilities range from small, desktop-scale systems to the large facilities such as the aixCAVE, a 30 sqm visualization chamber which makes it possible to interactively explore virtual environments. More information about the VR Group:

http://www.itc.rwth-aachen.de/cms/IT-Center/Forschung-Projekte/~eubl/Virtuelle-Realitaet/?lidx=1