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ORIGINAL ARTICLE

The behavioral interaction of road users in traffic: An example of the potential of intelligent agent-based simulations in psychology

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Abstract This paper illustrates what psychologists can do and learn from the use of intelligent agent-based simulations, in combination with experimental designs, in order to model the behavioral interaction of motorists and motorcyclists in urban traffic, when motorcyclists ride in between the lanes of slow-moving or stopped vehicles. The results of the computer model were validated through a measure that estimates its agreement with the results of real-life traffic videos analyses. Lastly, this paper discusses the implications of adopting intelligent agent-based simulations in experimental psychology.

PALABRAS CLAVE
Agentes inteligentes;
Simulaciones basadas en agentes;
Métodos de investigación

La interacción conductal de conductores en el tránsito: un ejemplo sobre el potencial de las simulaciones basadas en agentes inteligentes para la psicología

Resumen Con un ejemplo se ilustra lo que los psicólogos pueden hacer y aprender al usar las simulaciones basadas en agentes inteligentes combinadas con diseños experimentales para modelar la interacción conductual de automovilistas y motociclistas en el tráfico urbano, cuando estos circulan entre los carriles de vehículos detenidos o circulando a baja velocidad. Los resultados del modelo computacional se validaron con una medida que estima su concordancia con los resultados obtenidos en análisis de videos de tráfico real. El artículo finaliza discutiendo las implicaciones que tiene para la psicología experimental la adopción de las simulaciones basadas en agentes inteligentes.

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Intelligent agents are well-known in computer sciences and artificial intelligence several decades ago (Wooldridge & Jennings, 1995) but their methodological relevance in social sciences is more recent (Axelrod, 1997; Troitzsch, 2009) and not so well-known to psychologists (Smith & Conrey, 2007). Intelligent agents are non-living objects that are conceived to resemble living organisms that interact among each other in certain types of environments. According to Wooldridge and Jennings (1995) the term *agent* has both a weak and a strong notion.

Roughly speaking, the weak notion of an intelligent agent defines them as a hardware or software-based computer system with the following properties: (a) autonomy (they behave without the direct intervention of humans, and have some degree of control over their actions and internal state); (b) social ability (they interact with other agents and humans by employing some kind of agent communication language); (c) reactivity (they perceive the environment that surrounds them, it may be the natural, physical world or a virtual environment represented in a graphical user interface) and (d) pro-activeness (they are able to show goal-oriented behaviors by taking the initiative). An agent is a sort of UNIX-like software process with the aforementioned characteristics. Concrete cases of this notion can be found, for example, in modeling human driving behavior in traffic (Bazzan & Klügl, 2013; Kesting, Treiber, & Helbing, 2009).

The strong notion of an intelligent agent defines them as computer systems that, in addition to having the properties of the weak notion, are either conceptualized or implemented using concepts that are more usually applied to humans (Wooldridge & Jennings, 1995). In artificial intelligence, for instance, agents can be characterized using mentalistic or emotional notions such as knowledge, belief, intentions and/or obligations. Concrete cases of these notions can be found in studies about the evolution of shame as an adaptation to social punishment in artificial societies (see for example, Jaffe, 2008). Intelligent agents, therefore, can be seen as a powerful research tool for studying physical, biological or social complex systems exhibiting the following two basic properties: (a) the system is composed of interacting agents which are seen as the ''microscopic'' elements of it and (b) the system exhibits emergent properties, arising from the interactions of agents that cannot be deduced simply by aggregating the properties of them to create a macroscopic level of the system. In other words, agent-based simulations represent a powerful methodological tool for psychologists who understand human or animal behavior from the point of view of social complex systems; a new field of science studying how parts of a social system give rise to the collective behavior of the system and how the system interacts with its environment and evolves over time (Wilensky & Rand, 2015).

Compared with other research tools in psychology, agent-based simulations have a broader scope. It allows the study of the individual behavior of agents not only in one moment (when comparing different groups of agents in just one period of observation) but also in their changes over time (by tracking their differences in several periods of observation). Thus, agent-based simulations allow the integration of different research designs in a single and coherent effort. Existent reviews on the use of intelligent agents in psychology (see for example Smith & Conrey, 2007) showed its potential by mentioning some examples of social simulations mainly developed by non-psychologists. Here I proceed differently. In the rest of this paper I show an example that illustrates, with some technical details, the use of intelligent agents as a research tool in traffic psychology.

Figure 1 A picture that shows the practice of motorcycle lane-sharing.

The effects of motorcycle lane-sharing on motorists' behavior

In a recent work, Correa (2015) developed an agent-based model of the behavioral interaction of motorists and motorcyclists in urban traffic, when motorcyclists ride in between the lanes of stopped or slow-moving vehicles as depicted in Fig. 1.

The social relevance of this phenomenon is widely recognized in Venezuela, where the rising sales of motorcycles has proliferated this practice of mobilization due to its benefits for commuting in congested traffic despite their safety implications (see Fig. 2). In the literature it has been reported that motorcycle lane-sharing has psychological implications for road users, due to the fact that motorists have negative attitudes toward motorcyclists and how they filter through traffic (Crundall, Bibby, Clarke, Ward, & Bartle, 2008).

In order to understand the source of these attitudes, the work presented an agent-based experiment to answer the following questions: (a) Does the practice of motorcycle lane-sharing impose a restriction for motorists to perform lane-changing maneuvers on the road? (b) Do the motorists need to accelerate and decelerate more often when sharing the lane with motorcyclists on the road? (c) What is the effect of motorcycle lane-sharing on the average