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Representativity and univocity of traffic signs and their effect on trajectory movement in a driving-simulation task: Regulatory signs

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ABSTRACT

Introduction: The effect of traffic signs in the motor behavior of drivers is not completely understood. Knowing how humans process the meaning of signs (not just by learning, but instinctively) will improve reaction time and decision making when traveling. The economic, social, and psychological consequences of car accidents are well studied. Every effort to find the solution of this social problem is encouraged. *Method*: This study identifies which traffic signs are more ergonomic for participants, from a cognitive point of view, and determines, at the same time, their effect in participants' movement trajectory in a driving-simulation task: the tracking task. *Results*: The results point out that the signs least representative of their meaning produce a quantitative and qualitative different deviation from the center of the road than the most representative ones.

According to the World Health Organization (WHO, 2013), worldwide governments have introduced a series of traffic-supporting-systems upgrades—such as separated roads for different vehicles (automobiles, motorcycles, or trucks), more visible junctions, or the decrease of the speed limit—in order to improve road safety. Nevertheless, 1.24 million people worldwide still die annually in accidents related to automobiles. Following Young and Stanton (2002), attention overload is the most cited factor in provoking these accidents. However, the influence of attention on driving requires more research.

In the laboratory context, a number of models have been proposed attempting to explain the general relationship between attention and movement (see Vilchez, 2013, for a review). By using driving-simulation tracking tasks, both attractive and repulsive effects to attentional cues have been found. These findings have been explicated based on the meaning that the cues have in a specific context (e.g., Vilchez, 2015; Vilchez & Tornay, 2012). In this sense, the impact of this influence of meanings on movement has been shown in the literature as proportional to its weight on subjects' representations (Buckingham, Cant, & Goodale, 2009; Buckingham & Goodale, 2010; Ganel & Goodale, 2003).

Previous, general attention-movement models do not predict this context-dependent effect based on mental representations. In this sense, new theoretical accounts have been proposed in the form of an original model. The premises of the so-called Meaning-Dependent Response Activation (MDRA; Vilchez, 2013) model are: (a) in a specific context, there are different mental representation for both non-targets (conceptualized as distractors in that context) and targets stimuli; (b) the kind of motor codification (attractive/repulsive) for stimuli depends on the representation of their meaning per se, plus the one individuals provide to them in a given context; and (c) the action-inhibitory mechanism is efficient but not completely effective in casting aside the competitive and unsuitable responses triggered by distractors.

Regarding the kind of attentional cues that produce an influence on movement, there is no significant difference of both endogenous and exogenous cues (Lee, 1999). In this sense, focusing on endogenous cues with directional meaning, it has been tested that participants interpret the same meaning of those signs differently depending on the context (Vilchez, 2015). In these studies, in a Y-junction, results showed that the representation of the deontic meaning of taking a determined road branch was altered based on the experimental setting in which the sign was presented. In complex environments, it was found to be a "mental repulsive effect" (in terms of Vilchez, 2015). That is to say, individuals displaced themselves to the opposite side of the road of the one that was signaled and being represented in their "working memory" (in terms of Baddeley & Hitch, 1974). The concept of "mental footnote" was used to explain the found effect.

In psychology of thinking, humans are proposed to represent propositions as real life states (Johnson-Laird, 1983), in other words, we reason based on analog representations of specific situations. Even in the case of negations, humans represent those propositions with a mental footnote denying such possibility (e.g., Braine & O'Brien, 1998). This concept of negation and mental footnotes was used by Vilchez (2015) to propose that, when individuals were representing the direction they had to take, a mental footnote of "not yet" was activated in their

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system. That is to say, they did not have to carry out the proper movement at that very moment and, therefore, the iconic representation of what they would have to do was not suitable at that time yet. This mental footnote provoked that participants did displace themselves to the opposite side of the road branch that they were representing to take.

The direction of the effect is based on the "ideomotor phenomenon" (in terms of Carpenter, 1852). When individuals represent a movement, they activate the system on the same manner as they were carrying out that precise movement. An inhibitory mechanism is activated to stop the action if not proper. Nevertheless, taking into account that the inhibitory mechanism is not completely effective and by using sensitive means, it is possible to notice and measure this slight activation of the motor programing on a behavioral manner (cf. Vilchez, 2016).

All in all, Vilchez (2015) demonstrated how dangerous the consequences of a misprocessing of traffic signs are. Say that individuals are driving on the right lane of the road, if the environment in which a turn-on-the-right sign is not appropriate, this non-cognitive-ergonomic setting could make drivers displace to the left; invading the left lane, where it is possible that a car driving through the opposite direction could be coming. In this sense, recent research has shown that signs, that have not been well-understood, attract the movement to themselves (Vilchez, 2016).

1. Research objectives

The influence of attention on movement has shown to provoke non-desired, collateral consequences, even with implications for individuals' safety (e.g. Vilchez, 2015; Vilchez, 2016; Vilchez & Tornay, 2012). On the other hand, there are hundreds of traffic signs that are not verified in either their cognitive processing or their effect on movement. Therefore, the aim of this work is to assess both how individuals understand traffic signs and how these signs affect their decisions and their motor behavior (cf. Vilchez, 2016).

2. Experiment 1

In this first experiment, participants had to decide if a traffic sign presented at a precise moment corresponded to the definition of the sign presented beforehand. RTs were measured in response to the presentation of a series of traffic signs. Two concepts were dealt with (cf. Vilchez, 2016): (a) if the sign really represents its meaning (representative sign), before the right matched definition-sign, RTs will be shorter than when the sign does not represent that meaning; (b) if the sign is not ambiguous (univocal sign), before the wrong matched definition-sign, RTs will be shorter than when the sign is

Fig. 1. Regulatory sings tested in their representative and univocal meaning.

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