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Psychophysiological, subjective and behavioral differences between high and low anger drivers in a simulation task

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ABSTRACT

Anger is one of the important human factors in the prediction of road accidents. The aim of this research was to analyze the psychophysiological, subjective and behavioral differences between a high-anger driver group ($n = 15$) and a low-anger driver group ($n = 23$) in a driving simulation task. The results showed that high-anger drivers drove in general faster than low-anger drivers ($d = 0.83$), had more accidents ($r = .41$), a higher physiological arousal according to heart rate ($\eta^2 = .11–.18$) and electromyography ($\eta^2 = .10–.11$) in several driving situations. It was also shown that they scored higher in state anger immediately after the simulation task ($d = 0.82$) and lower at perceived respect of the traffic rules ($d = -0.76$), as well as displaying lower rates of attention during the simulation task ($d = -0.80$). In the second part, correlations among the variables were analyzed. State anger was the only variable that was significantly associated with the three behavioral variables: mean speed ($r = .45$), infractions ($r = .31$) and number of crashes during the task ($r = .46$). Clinical and road safety implications of these results are discussed.

1. Introduction

One of the specific contexts in which human behavior must be studied is that of driving a motor vehicle, because road accidents cause many deaths and debilitating injuries around the world. Three factors have been identified in road safety: vehicle, environment and human factor. Among them, human factor accounts for more variance in road accidents than vehicle and environment factors do (Evans, 1991). Therefore, due to the complexity of this context, the specific study of the physiological, subjective and behavioral responses that drivers show while driving is necessary.

The variable human factor which is generally considered most relevant in road accidents is that of anger (Dahlen & Ragan, 2004; Deffenbacher, Lynch, Filetti, Dahlen, & Oetting, 2003; King & Parker, 2008; Mann et al., 2007; Shaikh, Shaikh, & Siddiqui, 2012). The experience of this emotion has been shown to have a negative effect on several cognitive variables, such as attention span, perception and information processing, which are essential to driving (Bone & Mowen, 2006; Deffenbacher, Deffenbacher, Lynch, & Richards, 2003; Sullman, Stephens, & Yong, 2014).

In the same way, some comparative studies between high-anger and low anger-drivers have been carried out, showing that high-anger drivers commit more traffic infractions than low-anger drivers (Underwood, Chapman, Wright, & Crundall, 1999). Moreover, in laboratory studies conducted through simulation tasks, anger experience has been linked to loss of

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vehicle control, loss of concentration and a higher probability of suffering an accident (Deffenbacher, Lynch, Oetting, & Yingling, 2001; Deffenbacher, Lynch, et al., 2003).

Regarding the physiological correlates of anger, cardiovascular indices are the most utilized because they differentiate best between high and low anger states, more specifically heart rate (HR) and blood pressure (Ax, 1953). Therefore, it has been demonstrated that a significant increase in both HR and blood pressure is observed when anger is experienced, in comparison to a calm state (Ellis, Vanderlind, & Beevers, 2013; Gautam, 2013; Jackson, Kuppens, Sheeber, & Allen, 2011; Uchiyama, Hanari, Ito, & Takahashi, 1990; Vrana, 1993). Similarly, these findings have been replicated in the driving context, so HR, as well as blood pressure, increases as a direct consequence of stressful events (Stokols, Novaco, Stokols, & Campbell, 1978). Also some characteristics of the road, such as the degree of curvature of a stretch, affect the level of difficulty (Richter, Wagner, Heger, & Weise, 1998). Thus, in general it has been observed that cardiovascular measurements are the ones that differentiate best between high and low-anger drivers (Galovski, Blanchard, Malta, & Friedenberg, 2003; Galovski, Malta, & Blanchard, 2006; Malta et al., 2001). However, some studies did not verify this relationship. For example, in a driving simulation experiment it was found that HR correlated with anxiety, but not with anger (Mesken, Hagenzieker, Rothengatter, & de Waard, 2007).

Secondly, electrodermal activity has been analyzed. It appears useful to distinguish between the levels of anger and hostility, although electrodermal activity does not yield as much precision as cardiovascular measurements (Ax, 1953). Modern empirical studies are not consistent about this relationship. Some of them have found that there is no association between the experienced anger and the electrodermal activity (Gallo, Smith, & Kircher, 2000), but others have obtained significant relationships (Kubo, Okanoya, & Kawai, 2012). Regarding the specific context of driving, this inconsistency is also observed. In a virtual reality study, in which one group was anger-induced and the other one was not, it was found that there was no difference in electrodermal activity between the two groups (Macedonio, Parsons, Digiuseppe, Weiderhold, & Rizzo, 2007). However, thanks to two studies, it has been found that there are significant relationships between anger and electrodermal activity, hence why an increase in anger covariated with skin conductance (Hulbert, 1957; Malta et al., 2001).

The third physiological index that has been utilized to measure anger is electromyography (EMG). In comparison to the previous two indices, EMG has the particularity of measuring the somatic nervous system rather than the autonomic nervous system. Some studies have demonstrated that anger level covariates with muscle tension in certain areas, such as orbicularis-oris (Fridlund, Schwartz, & Fowler, 1984), corrugator (Dimberg, 1988; Slomine & Greene, 1993) and flexor of forearm (Huis Iń t Veld, van Boxtel, & de Gelder, 2014). However, this physiological arousal covariates also with other variables, such as the effort exerted to carry out the task, as well as the mental exertion (Boiten, 1996; van Boxtel & Jessurun, 1993). Similarly, it has been observed that anger correlates with a facial muscular activity pattern, which differs from that of other emotions such as fear (Stemmler, Aue, & Wacker, 2007; Stemmler, Heldmann, Pauls, & Scherer, 2001), even when it is not verbally expressed (Schwartz, Fair, Salt, Mandel, & Klerman, 1976). Regarding the specific context of driving, the relationship between anger and muscle tension has been verified. There is a study in which an increase in anger was observed (measured through EMG), comparing it to the base line, when sounds referring to road aggression were presented. There were two groups: one composed of high trait anger drivers and the other one composed of low trait anger drivers. These groups did not differ in EMG base line. However, it has been observed that the increase of muscle tension was significant in the case of high trait anger drivers, while there was no significant increasing in muscular tension in the low trait anger driver group (Malta et al., 2001).

Regarding the methodology of the scientific study of driving, the use of driving simulators is becoming more and more frequent. There are several studies in which real-environment driving is compared to simulation-environment driving, supporting the ecological validity of the procedure. Thus, the similitude in driving behavior in the two environments in several variables has been verified, such as errors committed (Mayhew et al., 2011), visual attention span (Wang et al., 2010), number of accidents (Cox & Taylor, 1999; Reimer, D'Ambrosio, Coughlin, Kafrissen, & Biederman, 2006), speed, acceleration, overtakings, zig-zag driving behavior approaching STOP signs (Reimer, D'Ambrosio, Coughlin, Kafrissen, & Biederman, 2006), and general risky behavior behind the wheel, which are associated with safe/unsafe driving styles (Freund & Colgrove, 2008). Similarly, the similitude of driving according to the road design has been studied, such as driving in tunnels (Törnros, 1998) and through signposted junctions (Yan, Abdel-Aty, Radwan, Wang, & Chilakapati, 2008).

On the other hand, a strong similitude has been found in physiological reactivity, in both real and simulated environments, in several situations with different mental and emotional loads (Johnson et al., 2011; Kozenà, Frantik, & Nosek, 1999; Reimer & Mehler, 2011). This allows us to conclude that a virtual environment causes the immersion of the participant in the task ("get into the role"), which supports the validity of this procedure. Regarding the physiological indices analyzed in the three previously quoted studies, it was concluded that the cardiovascular ones were those which show most consistency between the two environments (real and simulated). They change very similarly according to the mental load implied in the situation in which drivers must drive (Mueller, Stanley, Azamian, & Mercer, 2013). Skin conductance has shown similar patterns across the two environments, although its utilization has been lower than that of cardiovascular measurements (Reimer & Mehler, 2011).

In conclusion, a large amount of research about anger behind the wheel has been conducted, although few studies have considered physiological variables. Besides, there are no studies that analyze the interaction of the three systems of response: physiological, subjective and behavioral (Lang, 1971). Therefore, the aim of the present research was to identify the main variables associated with driving anger when driving through an urban area. Then, drivers' behavior was analyzed when driving through different types of road designs (i.e. 4-way cross intersections with traffic lights, T-intersections,