Psychosocial factors, perceived risk and driving in a hostile environment: driving through tunnels

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Abstract: A large part of the research on risk in driving has been related to the consumption of alcohol and other substances. However, few studies have analysed risk behaviour in relation to road infrastructure. It took the dramatic accident in the Mont Blanc tunnel to highlight the lack of knowledge about the human factor involved in tunnel accidents and about the factors affecting emergency situations in such settings. This study compares drivers' perceptions and emotions in relation to driving in tunnels with those provoked by driving on normal roads in the open-air. Furthermore, we explore the factors relevant to risk perception and risk behaviour in tunnels. A total of 458 drivers from Madrid (Spain) responded to a questionnaire on these aspects. The results indicate that tunnels provoke unpleasant feelings and greater perception of risk than roads open to the sky. In spite of these feelings and perceptions, participants drive riskily in tunnels. In this study, we analyse the factors related to perception of risk and driving in tunnels.

Keywords: emotions; perceived risk; perception of vulnerability; safety distance; self-efficacy; tunnel.

Reference to this paper should be made as follows: Arias, A.V., Mayordomo, S., Fernández, I., Martínez-Rubio, J.L. and Magallares, A. (xxxx) ‘Psychosocial factors, perceived risk and drivingin a hostile environment: driving through tunnels’, *Int. J. Global Environmental Issues*, Vol. x, No. x, pp.xx–xx.

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1 Why study of risky driving in tunnels?

Each year, approximately 1.5 million people die in traffic accidents, with another 50 million injured. This figure represents over 2.1% of world mortality, and makes road accidents the world's ninth commonest cause of death. A more detailed analysis of these accidents reveals that at least 71% are attributable to the human factor (WHO, 2004). The study of psychosocial factors associated with this risk behaviour, therefore, emerges as a priority field of research.

Nevertheless, it was not until the 1990s that there was a sudden upsurge in the amount of research on the topic, reflecting increased interest in the subject of road tunnels and driving in such conditions. This period also saw the setting up of study commissions on safe building materials and more 'friendly' tunnel designs; at the same time, the systematic assessment of European tunnels led to the publication of their ranking with regard to safety (RACE, 2005). Furthermore, it was stipulated that the construction of new tunnels should be subject to strict and costly regulations aimed at reducing the potential seriousness of accidents, at facilitating their use and at providing users with appropriate information while driving through them.

However, it should be pointed out that this recent interest in tunnel-related accidents and risks in no way corresponds to the frequency of accidents in tunnels. Statistics show that accidents are less common in tunnels than on roads open to the sky – indeed, practically all road accidents occur on open-air roads, with just 2% occurring in tunnels (SEGTÚNEL, 2005).

Even so, the disasters in the tunnels of Mont Blanc, Tauern and St. Gotthard, in which 39, 12 and 11 people died, respectively, highlighted the fact that the peculiar road infrastructure of tunnels was a crucial factor contributing to the catastrophic dimensions of such accidents. In fact, as a consequence of these three events, the late 1990s saw the development of new regulations for infrastructure in tunnels, culminating in the publication of a White Paper (European Transport Commission, 2001). In addition, the safety assessment processes for tunnels have been standardised.

The conclusion that can be drawn is that it was not the incidence of accidents in tunnels, but rather the social, institutional and media-generated alarm that triggered this process of research, investment and regulation. Indeed, and although it may appear paradoxical in the light of the statistics, it seems that the social repercussions of these tunnel accidents are far greater than those of accidents that occur on open-air roads (and whose rates are incomparably higher). This is why, and although with some delay compared to other social agents, psychologists must undertake a specific analysis of risk behaviour in tunnel driving, and the peculiar reactions produced by this type of road conditions.

The two main sources that have guided the identification of the most relevant factors in risky driving behaviour on open-air roads are the Psychology of Health and research on decision-making. Specifically, the dominant approach in the study of risk behaviour is based on Azjen's (1988) Theory of Planned Behaviour (TPB). This model argues that behaviour is predicted, directly, by behavioural intention, which is in turn determined by attitudes, subjective norms and perceived control. Several authors have applied this model to predict risk behaviour, reflecting its perceived relevance for explaining road accidents (Blanco et al., 2000).

2 Limitations of the prevailing model in the study of risk behaviour. The experience of driving in tunnels

The present study departs from previous perspectives in two respects. First of all, our specific focus of attention is risky driving in tunnels. We consider there to be evidence that the mechanisms involved in tunnel driving differ from those involved in driving on roads open to the sky. Secondly, while we agree that the Ajzen's (1988) planned behaviour model (TPB) has explanatory value for risk behaviour on open-air roads, we consider the model to have serious limitations for studying the peculiar situation and experience of tunnel driving. We shall continue by presenting empirical evidence regarding the significant differences between the two types of driving, in support of our assertion concerning the limitations of the TPB model for the analysis of driving in tunnels.

Recent reports on the psychological aspects of road safety in tunnels suggest that the mechanisms involved in driving differ according to the type of road used. The data show that tunnels produce tension when overtaking and driving parallel to other cars; furthermore, drivers have a sensation of sideways movement, while tension is also produced to the presence of lateral walls. Such aspects lead to lower levels of perceived control and a greater feeling of danger. It has also been shown that in tunnels, more than on other types of road, drivers have greater sensations of claustrophobia and of discomfort cause by noise and experience an undefined sense of unease (SEGTÚNEL, 2005).

In addition to this evidence suggesting that, in tunnels, perceived control is lower and the emotional reactions are different from those occurring on other types of road, various studies confirm that perceptions of the infrastructures themselves also differ from perceptions relating to normal roads. Thus, tunnels are perceived as more hostile environments, and the potential consequences of accidents in them as more serious (Fernández et al., 2005). Finally, there is an evidence that tunnel driving has peculiar characteristics supporting the view that driving varies according to the type of road. Drivers are more cautious when driving in tunnels than on open-air roads, so that they are more likely to obey the rules of the road, maintaining safety distances, etc. (Rinalducci, Hardwick and Beare, 1979; Boer and Withington, 2004; Fernández et al., 2005).

Thus, there appear to be three types of variables that are especially relevant in tunnel driving, as compared to driving on normal roads: controllability, with regard to both the restrictions of the tunnel environment and the unforeseen events that can occur in them; the emotional reactions provoked by tunnel driving; the perception of risk, which is particularly heightened in this semi-closed setting.

The evidence presented above suggests that the TPB model excludes some of the most salient variables of driving in tunnels. Specifically, it excludes the emotional dimensions, the dimensions referring to the risk-perception construct and self-efficacy beliefs, all of which have been seen to more salient in tunnel driving.

Several authors have considered this range of variables, providing evidence of their impact on risk behaviour. We shall now consider the empirical evidence that point to the type of relationship between these factors and risky driving behaviour.

Perceived control is understood as the perception of internal obstacles (lack of ability or competence) and external or situational barriers (low accessibility or lack of collaboration from others). Thus, the measures most widely used consider a variety of beliefs about one's own ability to perform the behaviour. Numerous studies have shown the predictive power of perceived control in relation to behaviour, both direct and indirect (Rogers, 1975, 1983; Ajzen, 1991; Borgida, Conner and Manteufel, 1992; Albarracín et al., 2001). Likewise, the perceived control variable is considered central to the design of intervention programmes aimed at reducing risk behaviours (Ubillos and Navarro, 2003).

The self-efficacy construct refers to the belief about one's own capacity for producing a preventive response to a situation. Basen-Engquist and Parcel (1992) found self-efficacy to have direct and indirect effects on preventive behaviour. From Bandura's social cognition theory, self-efficacy is understood as the capacity for overcoming risks, suggesting that those who feel effective face potential risks as though they were challenges to be overcome; in sum, this conceptualisation implies a belief in the utility of behaviour to achieve a certain result (Bandura, 1977).

Analysis of the emotions, understood as the affective states experienced before, during and after performing the risk behaviour, was carried out by Caballero et al. (2003) and Carrera et al. (2005), in their studies on dangerous driving. The results indicate that intention to repeat the risk behaviour is better predicted by the emotional experience than by the TPB variables. These authors also reveal the significant role of emotional ambivalence on future behaviour: the joy-fear binomial predicts risky driving behaviour.

Finally, we shall consider in more detail the contributions of perceived risk to the study of risk behaviour. This construct, of which there are different definitions, is incorporated in the majority of behaviour prediction models. Soler and Tortosa (1987) define it as the assessment of and judgement about a potential danger to the person. Lee (1981), on the other hand, conceives of perceived risk as the product of the likelihood of occurrence of an adverse event and the probable consequences, while Otway and Thomas (1982) argue that perception can be understood as attitude – i.e. they stress the affective and evaluative aspects of perception.

Perceived risk is a central construct in many theories of health behaviour (e.g. the Health Belief Model of Janz and Becker 1984, or Rogers' Theory of Protection Motivation, 1983).

Some of these theories highlight the motivational nature of risk perception. Specifically, they propose that the perception of risk instigates the desire for self-protection and stimulates preventive behaviour (Rogers, 1983; Weinstein, 2003; Boer and Withington, 2004). Applied to driving, these theories suggest the motivational hypothesis that the perception of risk will result in less risky driving.

From a cognitive-motivational perspective, perceived risk reflects a conscious decision. Behaviour would be the result of a cost-benefit analysis of adopting this behaviour or not. An example of work from this approach is that of Brown and Groeger (1988), who conclude that the majority of road accidents affecting young people are due to the fact that they underestimate the true risks of their driving.

On the other hand, theories of emotion applied to risk perception focus on the study of the relationships between negative affect and perceived risk. From this perspective, Rundmo and Iversen (2004), e.g. understand perceived risk as worry about having an accident. These authors argue that it is those drivers that are worried about having an accident who are most likely to show protective behaviours, compared to those who are indifferent or those who tend to behave as 'sensation seekers'.

In sum, all these perspectives, and the data they contribute, would suggest that the relationship between perceived risk and self-protective behaviour is a positive one.

However, there are two types of evidence which indicate that the relationships between risk perception and behaviour are still far from having been understood. First of all, the meta-analyses carried out indicate that these relationships do not attain the expected effect size (Weinstein, Sandman and Roberts, 1990, 1991). And secondly, some studies have found negative relationships between risk perception and behaviour. The results of such work suggest that perceived risk would actually instigate risk behaviour. In this case, the findings have been explained on the basis of the accuracy hypothesis, which postulates that people base their perception of risk on the risk involved in their own behaviour. In consequence, the perceived risk in those who behave self-protectively will be less than in those who behave riskily (e.g. van der Pligt, 1998).

Various researchers have attempted to explain these conflicting results. Thus, Weinstein (2003) addresses the question of the weakness of the effects of perceived risk. In a field study, Weinstein, Sandman and Roberts (1990) found the correlations between risk perception and behaviour to range from 0.03 to 0.14. More recently, Brewer et al. (2004) have proposed the Reappraisal Hypothesis, which reconciles the apparent contradictions of the relationships between perception and behaviour.

Specifically, the suggestion is that there is a dynamic relationship between perceived risk and behaviour. The authors develop their proposal in two phases. They consider that initially (time 1) the perception of risk guides behaviour, and subsequently (time 2) it is behaviour that guides perception of risk. Thus, self-protective behaviours derived from an initial perception of risk (time 1) lead to a reappraisal of future risk (time 2). This proposal combines the predictions of the above-mentioned motivational and accuracy hypotheses (time 1 and 2, respectively).

Considering all of the studies mentioned above, it is clear that perceived control, self-efficacy beliefs, emotions and the perception of risk are highly relevant for a wide variety of behaviours. However, studies focusing on the psychosocial and behavioural factors involved in driving through tunnels are scarce. The present work attempts to deal with these issues. Specifically, its aim is to explore some of the relationships between the variables affecting driving in tunnels.

3 Objectives of the present study

Two objectives have guided the present work. First, to compare the psychosocial factors involved in driving on open-air roads with those involved in tunnel driving. For this, we considered the following factors: perceived control, beliefs of self-efficacy or utility of the behaviour, perception of risk and emotional reactions (assessed through diverse measures). As regards this objective, it was predicted that these factors would have greater impact on driving in tunnels than on driving on roads open to the sky.

The second objective was to analyse the structure of the relationships between the variables. We expected the relationships between these variables to permit the construction of a goodness-of-fit model that confirmed the importance of the variables in the prediction of risk behaviour in tunnel driving.

4 Method

4.1 Participants

The sample was made up of 458 drivers from Madrid, of whom 43.9% were women. Participants were aged between 18 and 74, and mean age was 38.57 (SD = 12.05).

The majority of the drivers (91.5%) stated that the motor car was the principal form of motorised transport they used. Mean number of years of driving experience was 16.97 (SD = 11.23), and mean frequency of driving was 5–6 times a week ($M = 6.01$ and SD = 1.49, where 1 = less than once a week and 7 = daily). The majority also frequently drive through tunnels: 93.4% reported having done so in the past year, and on average they drive through a tunnel 1–2 times per week ($M = 4.14$ and SD = 2.12, where 1 = less than once a month and 7 = daily).

4.2 Questionnaire and procedure

The sample of drivers in this study was recruited over a period of two weeks in the city of Madrid (Spain) by a private consultant. The data-collection instrument was a questionnaire with self-report measurement scales designed specifically for this research. A random sampling procedure was used for selecting the participants. Before carrying out the fieldwork, those applying the instrument were given training in the correct application of the questionnaire and instructed in the random-route procedure they were to follow.

The blocks of items in the questionnaire were as follows:

- Two items were used, safety distance and speed, in relation to participants' own driving behaviour: The safety distance item was: "What safety distance (in metres) do you usually keep when driving in a tunnel?" Finally, speed was excluded from the analyses due to the absence of empirical relationship with the studied factors. In the Conclusions section we offer a possible explanation of this lack of relationship.
- Two items referring to perception of control: "Imagine that you are driving and a non-frontal crash between two cars occurs just in front of you. Would you feel capable of controlling the situation and avoiding crashing… If it happened on a normal road (open to the sky)?" and "If it happened in a tunnel?" Responses were made on a five-point Likert-type scale (1 = totally incapable, to 5 = highly capable).
- An item referring to the utility attributed to one's own driving behaviour: "I think that for avoiding accidents, the safety distance I usually maintain is" .... Responses were made on a five-point Likert-type scale (1 = not at all useful, to 5 = very useful).
- Seven items referring to four dimensions making up perceived risk, on normal roads and in tunnels, in terms of:
  - a *Perception of seriousness* (Imagine a non-frontal crash between two cars... "How serious do you think the consequences would be... If the accident is on a normal road (in the open air)?", and "If it is in a tunnel?", responses were made on a five-point Likert-type scale (1 = not at all serious to 5 = very serious).
  - b *Inherent risk* ("I think driving in tunnels is"..., not at all risky (1) to very risky (5)).

c *Overestimations of risk* (In general, in tunnels there are... “more incidents than on normal roads”, and “more accidents than on normal roads”, 1 = totally disagree to 5 = totally agree).

d *Perception of personal vulnerability* (“What do you think is your probability of having an accident... On roads open to the sky (roads, streets, etc.)?” and “...In a tunnel?”, where 1 = none to 5 = very high).

- Two items referring to the estimated vulnerability to accidents of the general population, on normal roads and in tunnels, respectively: What do you think is the probability (in the general population) of having an accident on roads in the open air? And In a tunnel? Responses were made on a five-point Likert-type scale (1 = none to 5 = very high).
- With the four ‘perception of vulnerability’ items mentioned above, the illusion of invulnerability index (for normal roads and tunnels, respectively) was constructed. This bias refers to one of the dimensions of the optimistic view construct, specifically: people believe they have less probability than the general population of suffering negative events. Operationally, this bias is obtained by subtracting the estimated probability for oneself from the estimated probability for the general population (for normal roads and tunnels, respectively). If the result of this operation is positive, the person presents this cognitive bias (Ubillos, Páez, Mayordomo and Sánchez, 2003).
- Various items referring to the presence or absence of positive emotions (joy, security and comfort) and negative emotions (fear, nervousness and feelings of danger) when driving on normal roads and in tunnels.
- Five items referring to one’s feelings on driving through a tunnel: e.g. “The noise disturbs me or has a negative effect” (1 = totally disagree to 5 = totally disagree).
- Two items referring to knowledge of aspects related to driving and accidents: “Have you had specific instruction on driving in tunnels?” (0 = no, and 1 = yes); “How many people do you think died in road accidents in Spain last year?”.
- A question referring to previous direct or indirect experience of accidents: “Have you ever been affected directly or indirectly by a road accident?” (0 = no, and 1 = yes).
- Sociodemographic data: Sex, age, years of driving experience, type of vehicle driven, frequency of driving and frequency of driving through tunnels. The last two items were rated on a seven-point Likert-type scale (1 = less than once a month to 7 = daily).

Below we describe the principal results obtained for driving in tunnels vs. driving on normal roads open to the sky. The variables of reference were those described above. We also set out to examine the relationship between the perceived risk dimension and the rest of the variables covered by the questionnaire. The statistical analyses employed include analyses of variance, comparisons of means, correlations and regressions. Finally, we propose a path analysis model that describes the simultaneous relationships among the variables studied.

5 Results

In general, the sample presents scores close to the theoretical mean of the scale (three points) in feelings experienced on driving through a tunnel. Likewise, people who have had direct or indirect experience of a road accident, compared to those without such experience, more frequently report having different sensations when they pass through a tunnel ($\chi^2(4,456) = 10.20$, $p \leq 0.05$; $\rho(456) = 0.12$, $p \leq 0.05$). Nevertheless, negative sensations about the noise and the dark colour of the walls are fewer the more frequently participants drive in tunnels ($r(455) = -0.12$, $p \leq 0.01$ and $r(451) = -0.01$, $p \leq 0.05$, respectively).

Inherent risk and negative emotional experience present positive relationships with all the feelings experienced in tunnels; the same applies to overestimation of the number of accidents in tunnels (see Table 1). In turn, the experience of different sensations when driving in tunnels is positively associated with perception of seriousness ($r(454) = 0.01$, $p \leq 0.05$) and negatively with perception of control and positive emotions ($r(442) = -0.01$, $p \leq 0.05$ and $r(408) = -0.19$, $p \leq 0.0001$, respectively). Tension due to the darkness and geometry of the tunnel walls is also related negatively with positive emotions ($r(405) = -0.15$, $p \leq 0.01$ and $r(406) = -0.17$, $p \leq 0.01$, respectively), and positively with the perception of vulnerability ($r(448) = 0.14$, $p \leq 0.01$ and $r(406) = 0.13$, $p \leq 0.01$, respectively). Finally, a positive association is found between perception of seriousness and the disturbance of the noise in the tunnel and the darkness of its walls ($r(454) = 0.12$, $p \leq 0.05$ and $r(450) = 0.11$, $p \leq 0.05$, respectively).

Table 1 Relationships between feelings experienced in tunnels and inherent risk, negative emotions and overestimation of incidents/accidents in tunnels

	Inherent risk	*Negative emotions*	*Incidents*	*Accidents*
When I am driving through tunnels...[1]	*r*(*n*)	*r*(*n*)	*r*(*n*)	*r*(*n*)
Different sensations...	0.23* (452)	0.31* (422)	n.s.	n.s.
Veering to sides	0.22* (443)	0.22* (416)	0.20* (426)	0.21* (428)
Disturbing noise	0.24* (452)	0.21* (422)	0.20* (434)	0.18* (436)
The dark colour makes me tense	0.27* (448)	0.29* (419)	0.22* (430)	0.15* (432)
The geometry makes me tense	0.24* (448)	0.28* (419)	0.28* (431)	0.22* (432)

[1.] Scale (1) totally disagree to (5) totally agree. *$p \leq 0.01$; n.s. = non-significant correlation.

Focusing on the effects of driving in tunnels compared to driving on normal roads (see Table 2), we find that participants perceive the consequences of accidents to be more serious when they occur in a tunnel ($t(453) = 18.23$, $p \leq 0.0001$). Moreover, they believe that both they themselves and the general population are more likely to have an accident in a tunnel than on a normal road in the open air ($t(450) = 3.61$, $p \leq 0.0001$ and $t(446) = 3.09$, $p \leq 0.0001$, respectively). The difference of means between the perception of vulnerability for the general population and for oneself is significant both for driving in the open air ($t(448) = 13.02$, $p \leq 0.0001$) and driving in tunnels ($t(449) = 11.65$, $p \leq 0.0001$). However, no significant differences are found with respect to the illusion of invulnerability bias. In turn, participants perceive themselves as less capable of controlling an accident if it occurs in a tunnel than if it occurs in the open air

(t (443) = –14.71, $p \leq 0.0001$). Finally, respondents report more negative emotional experience (t (418) = 10.47, $p \leq 0.0001$) and fewer positive emotions (t (397) = –11.7, $p \leq 0.0001$) when driving in tunnels than when driving in the open air.

Table 2 Differences between driving in the open air and in tunnels

	Open air, mean (SD)	*Tunnel, mean (SD)*	***N***
Perception of seriousness[a]	3.66 (0.89)	4.28 (0.79)	454
Perception of vulnerability (oneself)[a]	2.76 (0.81)	2.88 (0.90)	451
Perception of vulnerability (general population)[a]	3.23 (0.80)	3.33 (0.83)	447
Perception of control[a]	3.61 (0.78)	3.05 (0.92)	444
Negative emotions[b]	0.36 (0.72)	0.81 (0.97)	419
Positive emotions[b]	2.34 (0.80)	1.75 (1.13)	398

[a]Five-point scale.

[b]Three-point scale.

The data we have presented appear to indicate that tunnels are perceived with some degree of suspicion. Nevertheless, the mean safety distance participants maintain (25 m) when driving through a tunnel is not satisfactory (bearing in mind that in Spain the legal minimum safety distance is 100 m). Having calculated percentiles 25 and 75 in this variable, we divided the participants into three groups (low-, medium- and high-risk), finding differences between the variables utility of the behaviour ($F(2, 450) = 4.56$, $p \leq 0.05$), perception of vulnerability ($F(2, 452) = 4.41$, $p \leq 0.05$) and illusion of invulnerability ($F(2, 449) = 11.81$, $p \leq 0.0001$). Post-hoc analyses using the Bonferroni statistic show that the high-risk participants, compared to the low-risk ones, attribute less utility to their safety-distance behaviour for avoiding accidents ($p \leq 0.05$) and present a greater perception of vulnerability ($p \leq 0.05$). Furthermore, low-risk participants, compared to those of medium and high risk ($p \leq 0.0001$), score higher in the illusion of invulnerability variable (see Table 3).

Table 3 Differences according to low-, medium- and high-risk drivers in utility, perception of vulnerability and illusion of invulnerability

	Mean (SD) (n)		
	Low-risk	*Medium-risk*	*High-risk*
Utility of behaviour[a]	4.3 (0.79) 113	4.08 (0.78) 217	3.98 (0.99) 121
Perception of vulnerability[a]	2.72 (0.99) 113	2.87 (0.87) 217	3.07 (0.89) 123
Illusion of invulnerability[b]	0.76 (0.96) 113	0.34 (0.74) 216	0.34 (0.71) 121

[a]Five-point scale.

[b]Rank of 1–4.

We shall now concentrate on the results in relation to perceived risk. We carried out an analysis of correlations (Pearson's r and/or Spearman's ρ) between inherent risk, perception of seriousness, perception of vulnerability and illusion of invulnerability and the rest of the questionnaire variables. The results show that inherent risk correlates negatively with specific instruction on driving in tunnels ($\rho(442) = -0.10$, $p \leq 0.05$), with perception of control ($r(441) = -0.12$, $p \leq 0.05$) and with illusion of invulnerability

($r(447) = -0.10$, $p \leq 0.05$). In turn, inherent risk correlates positively with overestimation of risk of incidents and accidents in tunnels ($r(432) = 0.27$, $p \leq 0.0001$ and $r(434) = 0.24$, $p \leq 0.0001$, respectively), with negative emotional experience ($r(420) = 0.15$, $p \leq 0.01$), with perception of seriousness ($r(452) = 0.19$, $p \leq 0.0001$) and with perception of vulnerability ($r(450) = 0.32$, $p \leq 0.0001$).

As regards perception of vulnerability, this correlates positively with overestimation of risk of incidents and accidents in tunnels ($r(432) = 0.26$, $p \leq 0.0001$ and $r(434) = 0.22$, $p \leq 0.0001$, respectively), with overestimation of number of deaths through road accidents ($r(416) = 0.12$, $p \leq 0.05$) and with negative emotional experience ($r(421) = 0.15$, $p \leq 0.01$), and negatively with perception of control ($r(440) = -0.15$, $p \leq 0.01$), with positive emotions ($r(406) = -0.19$, $p \leq 0.0001$) and with safety distance maintained ($r(453) = -0.11$, $p \leq 0.05$).

However, illusion of invulnerability correlates positively with safety distance ($r(450) = 0.27$, $p \leq 0.0001$), with perception of control ($r(437) = 0.14$, $p \leq 0.01$) and with positive emotional experience ($r(403) = 0.15$, $p \leq 0.01$), and negatively with overestimation of incidents in tunnels ($r(428) = -0.12$, $p \leq 0.05$). Finally, safety distance maintained also correlates positively with perceived utility of the behaviour ($r(451) = 0.15$, $p \leq 0.01$).

With the aim of further clarifying the role of perceived risk in the adoption of safe behaviour, we carried out a stepwise regression analysis with each of the perceived risk dimensions, taking as predictor variables those which presented significant correlations in the previous analyses.

The regression analysis on inherent risk gave three models, the first of which presents an R^2 of 0.10 ($F(1, 368) = 41.52$, $p \leq 0.0001$); in the second and third models, R^2 increases significantly (ΔR^2 (1, 367) = 0.05, $p \leq 0.0001$ and ΔR^2 (1,366) = 0.023, $p \leq 0.005$, respectively), giving a final explained variance of 42%. The most relevant predictive factors are, in order of importance, perception of vulnerability (standardised $\beta = 0.25$, $p \leq 0.0001$), overestimation of incidents in tunnels (standardised $\beta = 0.22$, $p \leq 0.0001$) and perception of seriousness (standardised $\beta = 0.15$, $p \leq 0.005$).

The regression analysis on perception of vulnerability presents an explained variance of 60% ($R^2 = 0.36$; $F(3, 336) = 61.56$, $p \leq 0.0001$). The significant factors are illusion of invulnerability (standardised $\beta = -0.54$, $p \leq 0.0001$), in a negative direction, overestimation of accidents in tunnels (standardised $\beta = 0.16$, $p \leq 0.0001$) and negative emotional experience (standardised $\beta = 0.10$, $p \leq 0.05$).

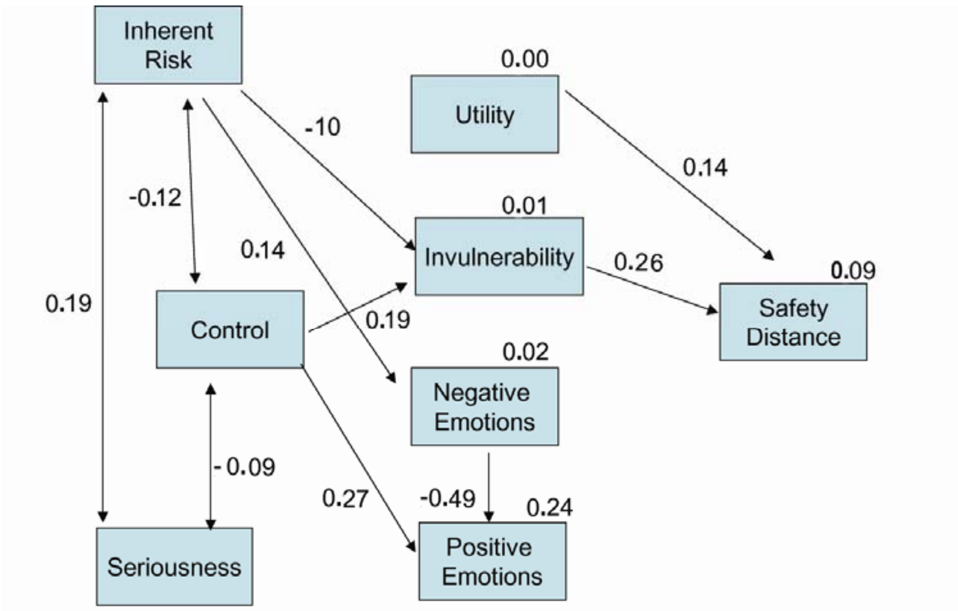
The stepwise regression analysis on illusion of invulnerability produced a single model. The R^2 is 0.03 ($F(1, 376) = 12.31$, $p \leq 0.001$), and the most relevant factor is perception of control (standardised $\beta = 0.18$, $p \leq 0.001$).

Finally, we carried out a regression analysis for safety distance given by the two models. The first presents an R^2 of 0.07 ($F(1,442) = 33.11$, $p \leq 0.0001$); in the second, R^2 increases significantly (ΔR^2 (1,441) = 0.02, $p \leq 0.01$). The second model explains 30% of the variance, and the most relevant factors are illusion of invulnerability (standardised $\beta = 0.26$, $p \leq 0.0001$) and utility of the behaviour (standardised $\beta = 0.14$, $p \leq 0.01$).

With the aim of analysing the relationships between the different variables in our study in a simultaneous manner, we carried out a path analysis used the AMOS Software, Version 4.0 (Arbuckle, 1994). We proposed a model with the purpose of studying the direct and indirect effects of the perceived risk dimension on the behaviour.

Initially, we took into account the three dimensions making up perceived risk, i.e. perception of seriousness, inherent risk and perception of vulnerability. Subsequently, the exploratory analyses carried out with the illusion of invulnerability variable gave a more satisfactory goodness of fit, so that we opted for using it in successive analyses (the reader will recall that illusion of invulnerability is the difference between estimated vulnerability for the general population and estimated vulnerability for oneself). We also include in the model variables that presented a direct relationship with the dimensions of perceived risk and/or behaviour studied (utility, perception of control, negative emotional experience and positive emotions). Finally, we include safety distance (see Figure 1).

Figure 1 Initial model on perceived risk

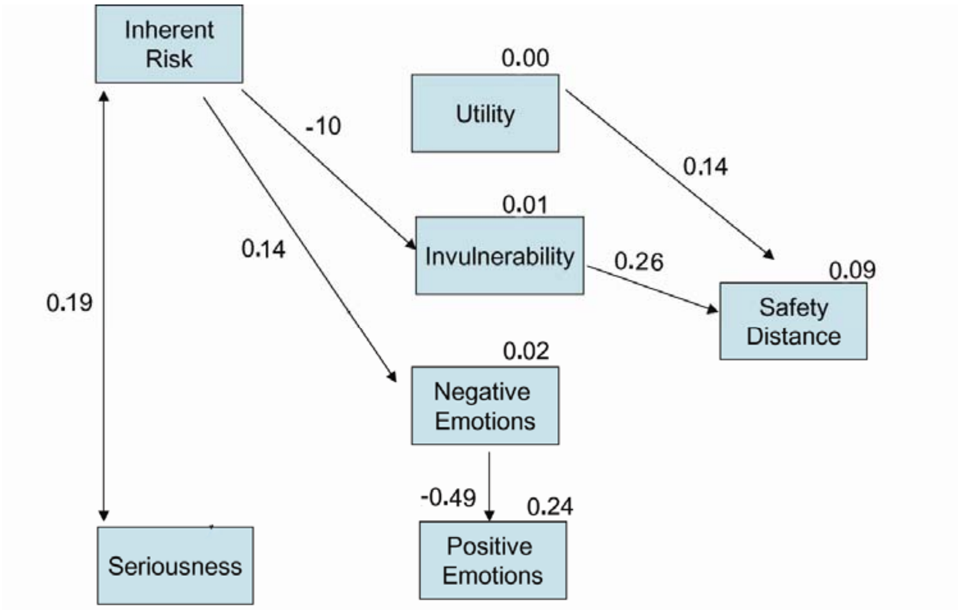


Note: Standardised estimations of the model. Values of the arrows correspond to the standardised regression coefficients (β). Values over the variables represent the percentage of explained variance (R^2).

The goodness of fit indices obtained for this model were not satisfactory ($\chi^2(18) = 37.63$, $p \leq 0.01$; Comparative Fit Index (CFI) = 0.91; Normed Fit Index (NFI) = 0.86; Residual Mean Squared Error Approximation (RMSEA) = 0.05). We re-specified the model, opting for elimination of the perception of control variable to obtain the acceptable fit (values between 0.95 and 1 for the CFI and NFI, according to Bentler (1990), and values below 0.05 for the RMSEA, according to Browne and Cudek, 1993).

The second model presented an adequate goodness of fit ($\chi^2(15) = 13.87$, $p = 0.54$; CFI = 1; NFI = 0.93; RMSEA = 0.0001). As it can be seen in Figure 2, this model postulates that the relationship between inherent risk and the behaviour is not a direct one, but is mediated by the illusion of invulnerability. The relationship between inherent risk and illusion of invulnerability is negative. On the other hand, illusion of invulnerability correlated positively with the behaviour. The utility attributed to the behaviour correlated positively with safety distance.

Figure 2 Final model on perceived risk



Note: Standardised estimations of the model. Values of the arrows correspond to the standardised regression coefficients (*β*). Values over the variables represent the percentage of explained variance (R^2).

Finally, emotions play an important role in the explanation of inherent risk. According to this model, risk is related directly and positively to negative emotional experience, and indirectly and negatively to positive emotions.

6 Conclusions

The majority of the studies on driving employ roads in general as the context of analysis. However, the present study departs from previous perspectives in its specific focus on risk driving behaviour in tunnels. We propose an alternative analysis to the prevailing model, which reveals the important limitations of the TPB for studying the peculiar situation and experience of tunnel driving.

The results presented here show that driving in tunnels has particular characteristics. The tunnel is perceived as a hostile environment. The darkness, the noise and the very geometry of tunnels are reported by our participants as stimuli that provoke unpleasant or disturbing sensations. This general impression is corroborated by the emergence of negative emotions when driving through tunnels. Moreover, this set of feelings experienced by our participants is directly related to the belief that driving in tunnels is risky. These data are in line with those of other research stressing the perceived danger in this driving context (Rinalducci, Hardwick and Beare, 1979; Boer and Withington, 2004).

More detailed evidence of the peculiarity of tunnel driving emerges on comparing it with driving on other types of road. The results obtained indicate that, in comparison with driving in the open air, positive emotions are less present, while negative emotional experience increases. When driving through tunnels, there is also an increase in participants' estimated probability of having an accident, the consequences of accidents are considered more serious, and their perception of control decreases. These results are similar to those found in a previous study, carried out with an incidental sample made up of 1,746 drivers from all over Spain (Fernández et al., 2005).

With regard to the illusion of invulnerability, no differences are observed between normal and tunnel driving. According to the anxiety management hypothesis (van der Pligt, 1995) the illusion of invulnerability fulfils a defensive function for dealing with stressful situations. In this regard, and as in other studies (Weinstein, 1989), our data do not confirm predictions suggesting that in more threatening environments there is greater illusion of invulnerability.

In the light of these results, it can be concluded that drivers' reactions in tunnels are peculiar to that context (Rinalducci, Hardwick and Beare, 1979), and, therefore, that there is a need to continue exploratory research in this driving environment.

With regard to the driving itself, we initially considered two measures of behaviour: speed and safety distance. Speed did not emerge as a measure sensitive to the different study variables. A possible explanation for this result lies in the recent introduction of radar speed monitoring in tunnels. Finally, we took as a measure of driving behaviour the safety distance drivers maintain in tunnels.

The results indicating the relationship of high risk with high perception of vulnerability, low utility of the behaviour and low illusion of invulnerability support the Accuracy Hypothesis (Brewer et al., 2004). These data leave us in no doubt: participants see quite realistically the possible negative consequences of their behaviour.

In sum, participants know the risks of their behaviour, and this leads us to consider the existence of a mechanism that permits them to persist in their risky behaviour despite this knowledge. In seeking a possible explanatory hypothesis, we might consider the effects of false consensus. The analyses carried out on this matter confirm that high-risk drivers estimate that other drivers are behaving equally risky. In our opinion, this biased view of reality may lead high-risk drivers to consider as tolerable or acceptable the risks they take (Beck, 1992) ("I do it, I admit, but I mean, everybody else does it", or "the external context or circumstances lead us to behave in this way").

As far as perceived risk is concerned, the results obtained in the correlation and regression analyses suggest that the measures of inherent risk, vulnerability, overestimation of accidents/incidents and perceived seriousness form a part of a risk perception construct. The data indicate that inherent risk is positively related to the other measures and is predicted by all of them. Nevertheless, it should be underlined that perceived vulnerability and overestimation of risk (measured as overestimation of accident/incident rates in tunnels) are independent of perceived seriousness.

Considering the relationships of the risk dimensions with the rest of the variables, it can be concluded that drivers with a higher perception of vulnerability will feel worse, will have less control and will consider the probability of having an accident as higher.

In general terms, our data support the existence of a partial relationship between perceived risk and the affective and cognitive dimensions relevant to the behaviour. As regards its relation to behaviour in tunnels, we can conclude that at least one of the indicators of perceived risk is related to the safety distance maintained. Once again, these relationships can be linked to the Accuracy Hypothesis. In sum, drivers who maintain a long safety distance consider themselves to have less probability of having an accident in a tunnel. In any case, this constitutes only a partial relationship between perception and behaviour, since the rest of the perceived risk indicators are not significantly associated with safety distance.

Overall, the proposed model ratifies the rest of the analyses and provides an overall view of the relationships between perceived risk, emotional factors, utility of the behaviour and risk behaviour in driving through tunnels.

Two suggestions emerge from this study. The first of these concerns methodology. The relationships between perceived risk and driving require examination through longitudinal studies that can clarify the possible relationships between perceived risk and behaviour. Such studies would permit researchers to examine potential bidirectional relationships between perception of risk and behaviour (Brewer et al., 2004).

The second suggestion relates to the applied context. We consider it necessary to carry out further research analysing specific driving factors and psychosocial mechanisms that explain behaviour in catastrophe and accident situations in tunnels compared to behaviour when such events occur in the open air.

Acknowledgements

The research reported in this article was supported by Ministry of Public Works Grant FOM/624/2003 (Área Sectorial "Construcción Civil y Conservación del Patrimonio Histórico Cultural" del Plan Nacional de Investigación Científica, Desarrollo e Innovación Tecnológica 2000–2003).

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