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Road-tunnel fires: Risk perception and management strategies among users

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Abstract

The present study was aimed at investigating road users' perceptions and behaviors in case of a fire in a tunnel. It is grounded on the idea that in order to effectively prevent accidents and fires in tunnels, it may be useful to take tunnel users' beliefs, representations, and coping strategies into account [Kouabenan, D.R., 1998. Beliefs and the perception of risks and accidents. Risk Analysis, an International Journal 18, 243–252; Kouabenan, D.R., 2001. Management de la sécurité: rôle des croyances et des perceptions. In : Lévy-Léboyer, C., Huteau, M., Louche, C., Rolland, J.P. (Eds.), RH: Les apports de la psychologie du travail. Les Editions d'Organisation, Paris, pp. 453–474; Kouabenan, D.R., Cadet, B., 2005. Risk evaluation and accident analysis. Advances in Psychology Research 36, 61–80; Kouabenan, D.R., Dubois, M., Scarnato, F., De Gaudemaris, R., Mallaret, M.R., 2007. Methicillin-Resistant *Staphylococcus Aureus* Risk Perception by Healthcare Personnel in a Public Hospital. Social Behavior and Personality, 35, 1] One hundred and fifty-one road users (firemen, truck drivers, regular drivers, and driving-school students) filled out a questionnaire measuring their perceptions of risks and control in road tunnels, their awareness of safety and rescue devices, their level of anxiety, and their behavioral intentions in the event of a fire in a road tunnel. The results indicated a relationship between fire-risk perception, awareness of rescue and safety devices, and road-tunnel experience; a tendency toward comparative optimism (CO); an effect of perceived control on optimism; and a relationship between CO and awareness of safety devices. A significant interaction was found between tunnel users' anxiety level and their perceived control over the situation. The evacuation behaviors and coping strategies reported by the participants were far from reflecting the expected behaviors. Recommendations for a long-term prevention policy bearing jointly on beliefs, behaviors, improved information and warning systems are suggested.

Keywords: Fire; Road tunnel; Risk perception; Safety; Prevention; Accident

1. Research objectives and issue

Road tunnels constitute essential public-works projects, from both a practical and an economic standpoint, because they limit the length of trips and thus reduce transportation time and costs. However, according to a brochure from the French Ministry of the Interior and Ministry of Transportation, Equipment, and Housing (Ministère de l'intérieur, Ministère de l'équipement des transports et du logement, 2000), catastrophic tunnel fires in the last seven years (Mont Blanc tunnel between France and Italy in 1999 with 39 deaths, Tauern tunnel in Austria in 1999 with 12 deaths and 60 persons injured, Saint Gothard tunnel between Switzerland and Italy in 2001 with 11 deaths, etc.) have led the public as well as European and French authorities to be more concerned with the safety of these structures and of the people who use them. Tunnels are particularly difficult to access during rescue operations. In crowded traffic conditions, it is hard for rescue vehicles to get

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around obstacles, and it is often impossible to get inside the tunnel to reach the scene of the fire. Furthermore, the enclosed nature of tunnel structures leads to rapid temperature increases during a fire and causes problems for ventilation and exhaust of fumes (see Benelux report on tunnel fire simulation; Boer, 2002). Today, more and more studies are focusing on improving smoke exhaust in the event of a fire and on learning more about tunnel users' behavior in such situations. For publications on this topic, see for example the UPTUN project report (Papaioannou and Georgiou, 2003), the ACTEURS project (Noizet et al., 2003), the Benelux fire study (Boer, 2002) and the present study, financed by the Rhône-Alpes Region of France. As a result of these studies, equipment upgrades have been made in order to improve incident detection in tunnels and enable users to quickly get to safety.

However, while technical progress in the area of tunnel safety is real, a mastery of the risks inherent in such structures also involves taking into account the risk-coping behavior of people, especially their perception of risks (Kouabenan, 1998, 1999, 2000; Kouabenan et al., 2001). Indeed, when a fire or accident happens in a road tunnel, users do not always evacuate according to the instructions they are given. For example, during the Mont Blanc catastrophe, 27 people among the 39 who died did not leave their cars, and two others who did leave their cars died in another vehicle where they had taken refuge (Brocquet, 2002). In the tunnel surveillance videos that we viewed, it was common to see users in fire situations leaving their vehicle and then returning to it to wait for rescue or to wait for several long minutes before evacuating the tunnel. Such attitudes are perhaps due to a failure to perceive the risks involved, an overestimation of intervention means, or a overly high assessment of one's ability to cope with risks.

Two difficulties related to informing the public before and during the breakout of a fire add to the problem. Firstly, given the diversity of tunnels (i.e., two-way vs. one-way, short vs. long, old vs. more recently built), users' awareness of available safety measures for themselves and for other tunnel users seems to be poor or incomplete. This type of information must therefore be provided on a case-by-case basis. Safety devices and measures for French tunnels vary according to the size of the tunnel, the type of tunnel, and the technical possibilities, a situation which makes it difficult to inform the public in advance about all existing safety provisions. Secondly, from the technical standpoint, information about a fire breaking out in a tunnel cannot be communicated to all drivers in a tunnel at the same time, so evacuation of a tunnel can only be accomplished with effective collaboration, not only among the drivers in the tunnel but also between the safety operators themselves and whatever users they are able to contact. In this sense, users who are told there is the fire and are informed of what to do become intermediaries for spreading this information, and as such, they become an integral part of the rescue system.

This article reports a study conducted within a broader research project financed by the Rhône-Alpes Region of France concerning fire prevention in road tunnels. Research teams from several different disciplines are involved. The study presented here deals solely with the psychological aspects of the project. In particular, we attempted to understand risk-management strategies implemented by tunnel users during fires by examining their representations of fire risk, their knowledge of safety and intervention devices, and their evacuation-related behaviors. The study is based on the idea that effective long-term prevention of accidents and fires in tunnels requires an understanding of the beliefs, representations, and coping strategies developed by populations directly concerned with fire risk and fire prevention in tunnels (Kouabenan, 1998, 2001, 2002; Kouabenan and Cadet, 2005; Kouabenan et al., 2007).

In this study, tunnel users are seen not only as agents responsible for their own and others' safety, but also as individuals whose actions are based on personal representations and beliefs (Kouabenan, 1999, 2001; Kouabenan et al., 2001). By viewing a road tunnel in the event of fire as a dynamic open system (Rogalski, 2003; Samurçay and Delsart, 1994), we postulated that any tunnel user who learns of a fire and is aware of the available safety or escape measures becomes, from that moment on, an actor who plays an integral part in the rescue operation. In reality, as mentioned above, when a fire occurs in a tunnel, not all users can be directly contacted and warned by safety personnel. However, those who are able to communicate with personnel can offer vital aid to others in the tunnel. The delegation of responsibility to tunnel users can only function effectively if they have a close-to-accurate representation of the risks involved, as well as a good knowledge of available courses of action. Clearly, the decision to evacuate can only be made after the assessment of available information about the immediate and imminent risks (Samurçay and Rogalski, 1993) and about who might be affected by those risks (oneself, others, a larger group, etc.). It is only through a better knowledge of tunnel users' fire-risk representations and awareness of safety devices that we can provide drivers with relevant information in real time, and that prevention measures likely to last – because they are geared to changing users' behaviors and attitudes – can be implemented.

The present study focuses on understanding two different phenomena: how users construct risk perceptions in tunnel-fire situations and how evacuation-behavior management evolves at both the individual and collective levels. In particular, our goals are to grasp how tunnel users with different experiences and practices in tunnels perceive fire-related risks, and to assess their awareness of intervention and rescue means, their degree of trust in the efficacy of these means, their cognitive strategies for coping with a fire, and any suggestions they might have regarding measures to combat fire dangers (safe areas, emergency exits, smoke-venting systems, alarms, etc.). We also look at users' perceptions of risks for themselves vs. risks for others (measure of comparative optimism), their perceptions of risk control and risk seriousness,