Improving users’ performance and safety at Station Pedestrian Crossings: a qualitative study

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SUMMARY

In order to improve safety at Station Pedestrian Crossings (SPC), a project was launched to develop a new safety equipment using a behavioural approach. This paper presents a qualitative study using focus groups to identify promising safety equipment concepts based on the theories of situation awareness and perception/action loop. Thirteen participants took part in activities and discussions involving scenarios simulation, mock-ups and questionnaires. Safety equipment elements embodying the theoretical aspects studied were analysed and their design improved to identify the most promising ones regarding pedestrians’ performance and safety, i.e. the ones inducing safe behaviours. Combinations of the latter were then evaluated to identity the best safety equipment concepts that will serve for the development of refined prototypes, the efficacy of which regarding safety at SPC crossings will be evaluated on a mixed-reality testing platform developed on purpose.

KEYWORDS

station pedestrian crossing, railway safety, safety equipment, focus group, situation awareness

Introduction

Station Pedestrian Crossings (SPC) enable pedestrians to cross rail tracks at grade in stations where there are no footbridges or underpasses. These crossings involve walking directly on rail tracks, which exposes users to a risk of collision with passing trains. In 2023, a project was launched to improve pedestrians’ safety at SPC. Major risks reported at SPC were the ‘another train coming’ risk, distraction of SPC users and social influence, which prompted the development of an approach based on users’ behaviour understanding. A first objective of the project was to investigate human behaviours and cognitive processes involved in the action of crossing a SPC and which could serve as levers for safety improvement. A literature review helped to identify situation awareness (SA) (Endsley, 1995) and the perception/action loop (Gibson, 1979) as relevant factors to study. A second objective was to develop a new safety equipment, the design of which would be guided by the theoretical factors identified.

Method

A qualitative study using focus groups appeared to be a suitable method to analyse human behaviours and to get users involved in the design process of safety equipment. Regarding the design of safety equipment concepts, the use of simulation and mock-ups appeared to be a good approach to make participants interact with design elements. Indeed, mock-ups allow for a simplified representation of environments and situations, which can be as effective as a detailed working prototype and less costly (Bell, 2007). Furthermore, it avoids the risks inherent to experimentations in real-life conditions (Watkins et al., 2008). Additionally, Karlsson (1996) indicates that the use of mock-ups and scenarios helps users express their needs. Four focus groups were therefore organised to generate the safety equipment concepts. Activities involving scenarios simulation and mock-ups for design improvement were developed. The focus groups sessions took place in a meeting room, around a table, and were led by a human factors expert (designated as *moderator* in the following) supported by an assistant for note-taking and material distribution.

Participants

The participants were thirteen unpaid volunteers (average age = 38,5±14,3, seven women, eight men), speaking French fluently, recruited through word of mouth and leafleting at train stations. They were users of French train stations, and non-experts of the railway sector and HOF domain. Twelve of them were familiar with pedestrian level crossings. They all had a good hearing and vision. The same panel was reconducted for each focus group to be efficient from one session to another and to go further in the analyses.

Materials

A 3D-reduced model of a small train station equipped with two platforms, a portion of a double-track railway, a SPC and various equipment (shelter, digital departures/arrivals board, dustbin, bench, ticket vending machine, platform numbers), as well as active safety device elements, were used to simulate scenarios (Figure 1). Furthermore, 2D mock-ups of a SPC and safety equipment elements were utilised by participants to generate design propositions (Figure 2). The 2D mock-ups of safety equipment elements were a mix of existing and innovative solutions designed on purpose by a partner on the project.

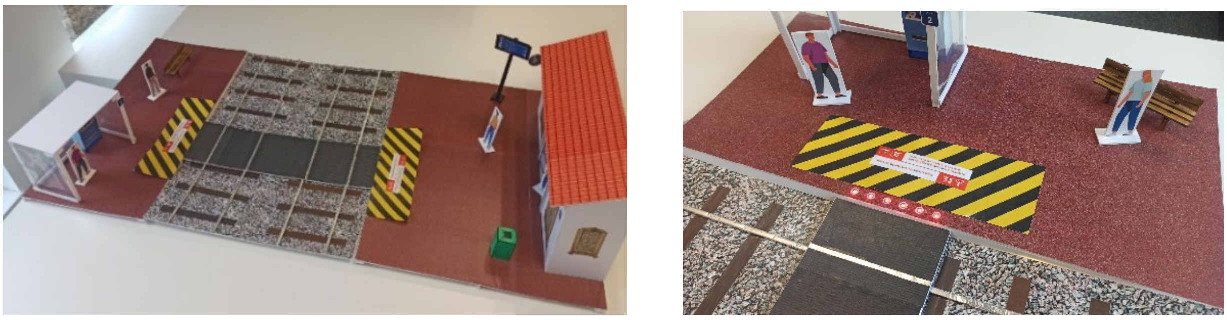

Figure 1: 3D-reduced model of a train station composed of two platforms, a portion of a double-track railway, a SPC (left); model of a safety device element shown activated (right).

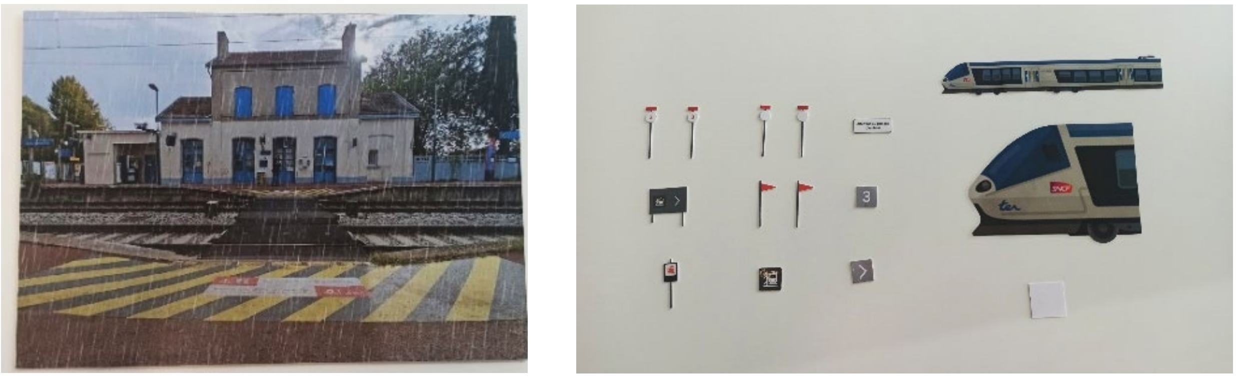

Figure 2: Example of the 2D mock-ups of a SPC (left) and safety equipment elements (right) used in the design improvement activity.

Procedure

The first three focus groups aimed at studying separately each theoretical aspect (levels of SA, perception/action loop) and identifying promising safety equipment elements enhancing these cognitive processes. The purpose of the fourth focus group was to compare combinations of equipment elements derived from the results of the previous focus groups, rank them and identify the most promising concepts regarding how well they guide users' behaviour and guarantee their safety at SPC. Each focus group was divided into two sessions, each session receiving half of the panel of participants. The groups of participants in each session varied from one focus group to another, which prevented the same participants taking the lead, supported an up-to-date understanding of the activities objectives, and guaranteed a renewal of ideas and results. The focus groups organisation is described in Figure 3.

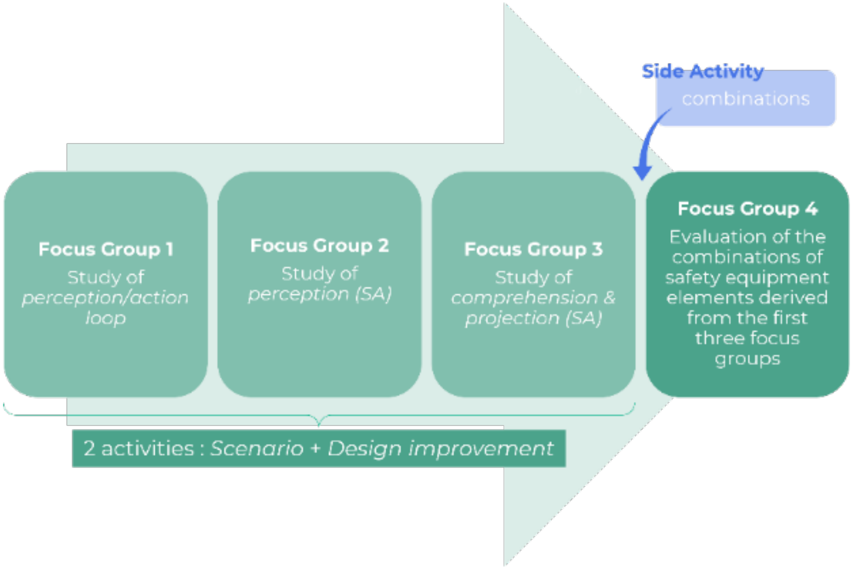

Figure 3: Focus groups organisation

The first three focus groups followed the same procedure. The idea was to present various safety equipment elements to the participants through scenarios, analyse the behaviours these elements induced and improve their design. In each focus group, the safety equipment elements used and the behaviours analysed were adapted in line with the theoretical aspect studied. The first focus group aimed at studying the *perception/action loop* (Gibson, 1979), i.e. see if safety elements would make participants stop spontaneously before the SPC when perceiving them. The second focus group studied the first level of SA (Endsley, 1995), *perception,* i.e. see if participants would detect well safety elements and interpret accurately the information they deliver (i.e. crossing ban). The third focus group focused on analysing the second and third level of SA, *comprehension and projection*, i.e. see if safety elements would help the participants understand different traffic situations at SPC (stopping train, passing train, 'another train coming' situation) and project the risk inherent to it (risk of collision with a train). The participants were not informed of the purpose of the study and did not know what activities to expect before the first focus group. The sessions were audio recorded. In a first activity (Activity 1), the participants were presented a **scenario** in which a fictional character had to achieve a goal inside a 3D-modelled train station environment implying the crossing of a SPC equipped with a safety equipment element shown activated (i.e. prohibiting the crossing of the SPC and announcing the approach of a train) (Figure 2, right). An example scenario was: "*Luke enquires for his train departure platform by looking at the departures board. The train is announced on platform 2. Luke is going on the corresponding platform to wait for his train.*". The participants had to explain what behaviours and actions the fictional character should put in place to achieve the goal, first through individual writings and then through a group discussion. This followed a *nominal group* approach (Gustafson et al., 1986) which gives everyone the opportunity to give their opinion and prevent the participants from getting biased by the others' answers. The group discussions would help the participants identify potential design flaws in the equipment element presented, related to the scenario situation, and give them ideas for the next step.

In a second activity (Activity 2), the participants were divided into groups of two or three people and given 2D-mock-ups of a SPC and safety equipment elements (Figure 2) to propose a **design improvement** of the safety equipment element encountered in the first activity. The technical functioning of the elements was presented on a screen in animated versions and left available for consultation. The design improvement was compelled by several instructions: the proposition should trigger the adequate behaviours / actions (relative to the theoretical aspect studied), a maximum of two safety equipment elements should be used, the participants had the possibility to suggest only one new element (drawn on a blank card), environmental and/or situational factors should be taken in account (weather conditions, trains traffic). The design proposition of each group was evaluated by the other participants through individual questionnaires and then discussed orally. The analyses of the questionnaires and discussions served to identify the most promising design propositions, and therefore, the most promising safety equipment elements for each theoretical aspect studied.

Between the third and fourth focus groups, a side activity was carried out by the moderator and other human factors experts on the project. The purpose of the activity was to give a more generic form to the safety equipment elements composing the best design propositions identified earlier in each focus group. This ensured that theoretical principles inherent to the elements were validated ahead of the fourth focus group. Combinations of these elements were generated based on the results of a subsidiary quantitative study conducted in parallel by partners on the project. These results indicated that most efficient safety equipment concepts should integrate elements of *perception/action* and *perception* (SA) (Principle 1) or elements of *perception/action*, *perception* (SA) and *projection* (SA) (Principle 2). From all the combinations identified, only the relevant ones were kept (i.e. redundancies and incoherent matches were removed).

In the fourth focus group, the combinations of generic safety elements defined in the side activity were shown in animated versions to the participants and in random order. Some combinations were shown with different design examples. Each combination was associated with a letter. Participants were invited to rank individually the combinations in relation to their potential to enhance performance and safety. For that purpose, each participant was given a ranking grid with repositionable letters corresponding to the combinations. Ranking was adjusted by the participants after each combination was shown. The four best ranked concepts were kept for the subsequent phases of the project.

Measures and analyses

The participants' individual writings from Activity 1 were analysed using task analysis and content analysis with the aim to assess their intuitive behaviour relative to the theoretical aspects embodied by the safety equipment element activated on the train station 3D model. The task analysis helped defining the expected behaviours and actions to be observed when crossing a SPC. The occurrence of specific combinations of verbal and thematic components in the participants' writings would indicate that they adopted the expected behaviours in front of the equipment element presented on the train station model. This gave an indication of the efficacy of the latter. For example, in the focus group dealing with *perception*, if the behaviours and actions expected corresponded to the SPC crossing task steps "Look at the signage" and "If signage is active, do not cross the SPC", a combination of verbal expressions equivalent to "Luke looks at the flashing light" and "He waits for the flashing light to stop before crossing" was expected in the writings. The content analysis of the group discussions allowed for a better understanding of the behaviours observed in the individual step and gave a first insight into good and bad design considerations.

The questionnaire filled in in Activity 2 used 6-points and 3-points Likert scales, as well as open questions. Several aspects of the design propositions produced were investigated: the efficacy of the solution (Dean et al., 2006 ; Cheeley et al., 2018) (i.e. in the present case, to what extent the proposition allows for a safe crossing), the theoretical aspect involved (*perception/action loop*: detectability and affordance of the solution; *perception*: detectability and interpretability of the solution; *comprehension and projection*: detectability and interpretability of the solution, comprehension of the global situation and projection of its evolution), the perceived usefulness of the solution (i.e. "the degree to which a person believes that using a particular system would enhance his or her job performance", Davis, 1989) and its perceived ease of use (i.e. "the degree to which a person believes that using a particular system would be free of effort", Davis, 1989). The total number of questions differed from one focus group to another, depending on the theoretical aspect studied. Each question was assigned a score contribution. These were summed to calculate the questionnaire total score. Scores of all questionnaires related to the same design proposition were averaged. The comparison of the average scores of each design proposition determined what the best ranked proposition in each focus group was. If the average scores of two propositions were equal or too close, a review of the comments made by the participants on the solutions (in the questionnaire open questions and during the group discussion) helped to decide the best ranked. It was made sure that these complied with the instructions given.

At the end of the fourth focus group, the participants' individual rankings of the combinations of generic safety equipment elements were averaged to obtain the four most relevant safety equipment concepts.

Limitations

- The panel of participants being the same for each focus groups, the participants might have expected the activities planned if they were similar to those of the previous focus group(s).
- The participants were not in real-life conditions and could only rely on the 3D model which has limits in terms of realism. Their projection in the scenarios given was therefore limited and different from what it would have been in real-life conditions, and so were their oral and written answers.
- There is a possibility that participants might not have fully understood the design propositions of other groups, which has an influence on the open answers and scores given.
- Participants have different behaviours regarding scores allocation which questions the use of average scores to obtain a ranking of the design propositions. This was balanced by the consideration of participants' written and oral comments.

Results

Seven safety equipment elements were extracted from the most promising design propositions identified in the first three focus groups. The side activity allowed to derive six generic safety elements from the elements previously extracted, two per studied thematic. Among all the combinations generated from these generic elements, thirteen were kept and were then ranked by the participants in the fourth focus group. The combination rankings of all the participants were found to be similar, with four safety equipment concepts standing out by far from the average ranking and bringing a quasi-consensus in the participants' discussions that followed regarding their potential to enhance safety and improve users' behaviour at SPC. The multiple results and the discussions pinpointed several design guidelines for the development of a safety equipment at SPC.

Conclusion

The methodology used helped to generate a wide range of solutions with the potential to improve safety, from single safety elements addressing target individual human factors such as attention, perception and comprehension, to combined equipment enhancing users' overall situation awareness. The study of each theoretical aspect individually helped to build technological assets.

The accumulation of these assets through the succession of focus groups ensured an improved user's performance and safety at SPC. Users' involvement allowed for the expression of various viewpoints, going beyond a technical expertise of the studied systems. Four generic safety equipment concepts were identified, with a quasi-consensus between participants regarding their potential to enhance safety and induce adapted users' behaviours. The concepts were not opposite to each other but were rather an improved version of the concept of lower rank. The next step will be to combine the results of the qualitative study with those of quantitative and technical studies to settle on final improved concepts to be tested in the next phases of the project, that are tests in a mixed-reality environment. In order to implement mixed reality, a testing platform has been developed. It consists of a virtual environment synchronised with a scale 1:1 modular physical platform (Figure 4). The testing platform is set to be adaptative so that any environment can be modelled in detail. For the purpose of the project, part of a train station is being recreated in both virtual and physical environments including two trains station platforms, a portion of a double-track railway and a SPC. Behavioural, physiological and kinematic data will be collected from the participants and recorded using a VR headset and cameras. These measures will help evaluate more precisely the impact of the safety equipment concepts on users' behaviour and safety at SPC, before an implementation in real-life settings.

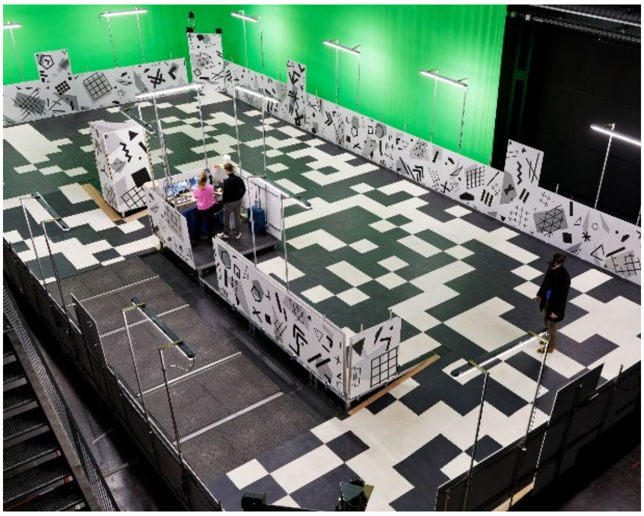

Figure 4: Mixed-reality testing platform developed

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