

Pedestrian exit choice behavior during an evacuation - a comparison study between field and VR experiment

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4 VR experiment

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1 INTRODUCTION

2 Understanding pedestrian exit choice behavior during emergency situations is important for
3 improving evacuation efficiency. Previously, different experimental studies have been performed
4 to collect data and study pedestrian exit choice behavior during evacuations. These experimental
5 methods include observations of real-life evacuation situations (1–3), controlled laboratory
6 experiments under stressed conditions in the real world (4–6), and surveys and questionnaires (7–
7 9). Yet, for studying pedestrian choice behavior in emergency situations, the performance of
8 experiments is restricted by several constraints (e.g., ethical and financial constraints, the balance
9 between the level of realism and invasiveness, and the level of participants' engagement) (9).

10 In light of these constraints, researchers have begun to explore Virtual Reality (hereafter
11 named VR) as a novel technique to investigate pedestrian evacuation behaviors (10-12). To date,
12 the usefulness of VR for studying pedestrian behavior is under discussion and this technique still
13 needs to be further explored and validated. In order to develop VR as a valid technique to study
14 pedestrian behavior, empirical evidence is needed to validate VR in comparison to other research
15 techniques. Therefore, it is necessary to perform VR experiments and real-world field experiments
16 under similar circumstances and to compare the results.

17 The present study investigates whether VR can be used to study pedestrian exit choice
18 behavior during an evacuation. This study compares exit choice behavior during a real-life
19 evacuation drill and a VR experiment that covers the same situation. The analysis focuses on the
20 comparison of the commonalities and differences in the pedestrians' exit choice during the field
21 observation and the VR experiment of the evacuation drill.

23 METHODOLOGY

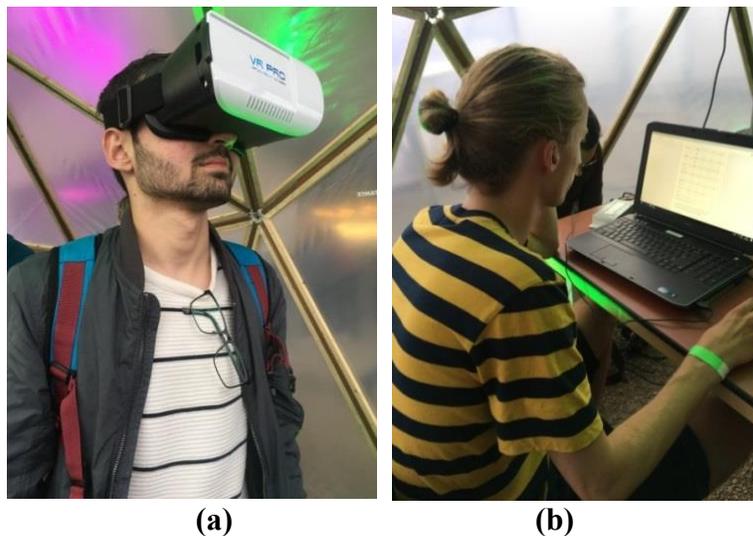
24 To study whether the pedestrian behavior in the real world and the virtual world aligns, the
25 research objective is: (1) to compare pedestrian exit choice behavior during an evacuation scenario
26 using two experimental techniques; and (2) to investigate whether VR can be used to study
27 pedestrian exit choice behavior during evacuations.

28 To achieve the objective, we carried out two experiments to study the exit choice behavior
29 of pedestrians during evacuation when they are faced with either a real-life environment or a VR
30 environment and compared the commonalities and differences in exit choice. More specifically, in
31 order to have a full-scale observation of exit choice behavior during evacuation, we recorded an
32 unannounced evacuation drill in a university building. The experimental area was a space with
33 multiple exits, in which participants could see all exits from their current location (Figure 1). The
34 exit choice of the participants of the observed evacuation drill could be observed from the video
35 recording.



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38 **FIGURE 1** A screenshot of 360° view of the workshop space by the Nikon 360 Camera.

1 Furthermore, the exit choice behavior of participants was investigated in a VR
2 environment that mimicked the situation of the field experiment. The collected data was two-fold:
3 (1) exit choice behavior and (2) participants' experience regarding the VR experiment. The
4 procedure of the VR experiment included the following parts: participants 1) were introduced to
5 the purpose of the experiment; 2) got familiar with the VR environment and the HMD device with
6 the general scenario; 3) were presented with the scenario of the evacuation drill and chose one exit;
7 4) filled in the questionnaire (Figure 2). The questionnaire contained four sections: participants'
8 information; the Simulation Sickness Questionnaire (13), which determined if participants
9 experience sickness throughout the experiment; the System Usability Scale (14), which assessed
10 usability of the applied VR system as a pedestrian simulator; and the Presence Questionnaire (15),
11 which measured user's sense of presence in the virtual environment.
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FIGURE 2 Participants were (a) experiencing the virtual experiment and (b) filling in the questionnaire.

19 With the collected data, we analyzed pedestrian exit choice behavior in both experiments.
20 Firstly, the statistics of the participants are described. Secondly, the exit choice from the
21 evacuation drill and the VR experiment are compared and the commonalities and differences of the
22 exit choice behavior between the two experiments are discussed. Finally, the relative validity of
23 the VR experiment was tested via the Pearson chi-square test. The null hypothesis is formulated as
24 follows: the exit choice behavior during evacuation does not depend on the experimental method.
25 In the following sections, the results of the two experiments are discussed and the conclusions are
26 made.

27 28 **FINDINGS**

29 During the real-life evacuation drill, 15 pedestrians chose exit A1 and 9 pedestrians chose exit C.
30 The other exits had not been chosen. In the VR experiment, 13 participants chose exit A1, 10
31 participants chose exit C and 3 participants chose exit E. No other exits had been chosen (Table 1).
32 Although the results of exit choice are similar for both experiments, there are some differences in
33 exit choice behavior. In comparison, 3 participants chose exit E in the VR experiment, either
34 because its visibility was good or because they were very familiar with the environment.
35

TABLE 1 The observed exit choice of the field experiment and the VR experiment

Exits	A1	C	E	Total
Field observation	15 (62.5%)	9 (37.5%)	0	24
VR experiment	13 (50%)	10 (38%)	3 (12%)	26
Total	28	19	3	50

The relative validity analysis shows that the methodological differences between the two experiments do not result in significantly different exit choice behavior during the evacuation. The result indicates that VR could be considered to be relatively valid as a research tool regarding exit choice behavior during evacuations.

Our observations during the VR experiment and the results of the questionnaire filled in after the VR experiment disclosed that none of the participants showed any signs of feeling uncomfortable or asked to have a break during the experiment. However, one participant did not understand the navigation and got lost in the VR environment during the experiment. In general, participants stated that the virtual environment was immersive and the equipment was easy to use.

CONCLUSION

The results show that the pedestrians' exit choice behavior during the evacuation is overall similar in the evacuation drill and the VR experiment. In both experiments, the following behavior was found to be the main factor influencing the pedestrians' exit choice behavior. Next to that, the distance and visibility of exits were found to influence exit choice behavior. Combining participants' experience in the VR experiment with relative validity analysis, we conclude that the use of VR can be considered as a valid tool for research on exit choice behavior during evacuations.

The present study has some limitations. Although the used HMD device is easier to operate and quicker to set up than more elaborate VR devices, some features such as eye tracking and interaction functions were missing. Thus, the next steps in this research include enhancing the improvement of the experimental method to use the tools can set up more complex simulations to study pedestrian behavior within different levels during an emergency situation, and extend the present method as an exploratory study to understand how different variables (e.g. infrastructures and information) influence pedestrian evacuation behavior.

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