A virtual experiment on pedestrian risk assessment in the presence of different threats

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Abstract This paper presents a virtual experiment to investigate how pedestrians assess risks when facing different threats that vary in how localized and spatially predictable they are. We adjusted the proportion of NPCs (non-player characters) choosing two available exits and used the exit choices of human participants to evaluate whether they would choose an exit closer to a threat but with less congestion and whether the proportion of such decisions is related to their ability to predict threat changes.

Keywords Different threats, Risk assessment, Exit choice, Virtual experiment

Introduction

The mechanisms influencing pedestrian movement decisions are important and have been investigated widely. Among these, exit choice is one of the most common movement decisions during evacuations. Examples include a virtual experiment on pedestrian exit choice, in which the number of NPCs (non-player characters) choosing different exits was varied to observe its impact on participants' exit decisions [1] and experiments conducted under emergency conditions that found that pedestrians chose different evacuation exits before and after becoming aware of the incident location [2].

In general, the exit choice of pedestrians depends on the evaluation of the utility of different exits. This utility primarily can depend on the evacuation time required for each exit choice, which is influenced by the pedestrian's distance to the exit and the level of congestion. In emergency situations, this utility also includes whether pedestrians can safely evacuate through a given exit, which means that the relative distance between the exit and the threat must also be considered.

Currently, research on how pedestrians assess the risks of exits when facing different threats remains relatively limited. Here, we present a virtual experiment in which participants have to choose between two exits in the presence of one out of three types of threats. The difference between different threat types lies in the varying degrees of predictability in their movement characteristics. For simplicity, we refer to the three threats as fire, earthquate, moving threat. Our fire threat is highly predictable, with a simple and intuitive spread pattern. For our moving threat, participants can observe its location and movement direction in real time but cannot determine how the threat selects the targets. In contrast, our earthquake threat is unpredictable, with new danger zones randomly generated at intervals (akin to falling debris during an earthquake). We recruit participants and analyze their exit choices to evaluate the impact of different threats on how pedestrians assess exit utility.

Experimental Setup

In this experiment, we built the experimental scenario based on the Qt Creator platform and set up three different types of threats, as shown in Figure 1. The figure shows the evolution of different threats over time to illustrate the varying degrees of predictability (left-right). The initial position of each threat was placed in the center of the lower wall. This means that at the beginning of the experiment, the lower left exit was closer to the threat.

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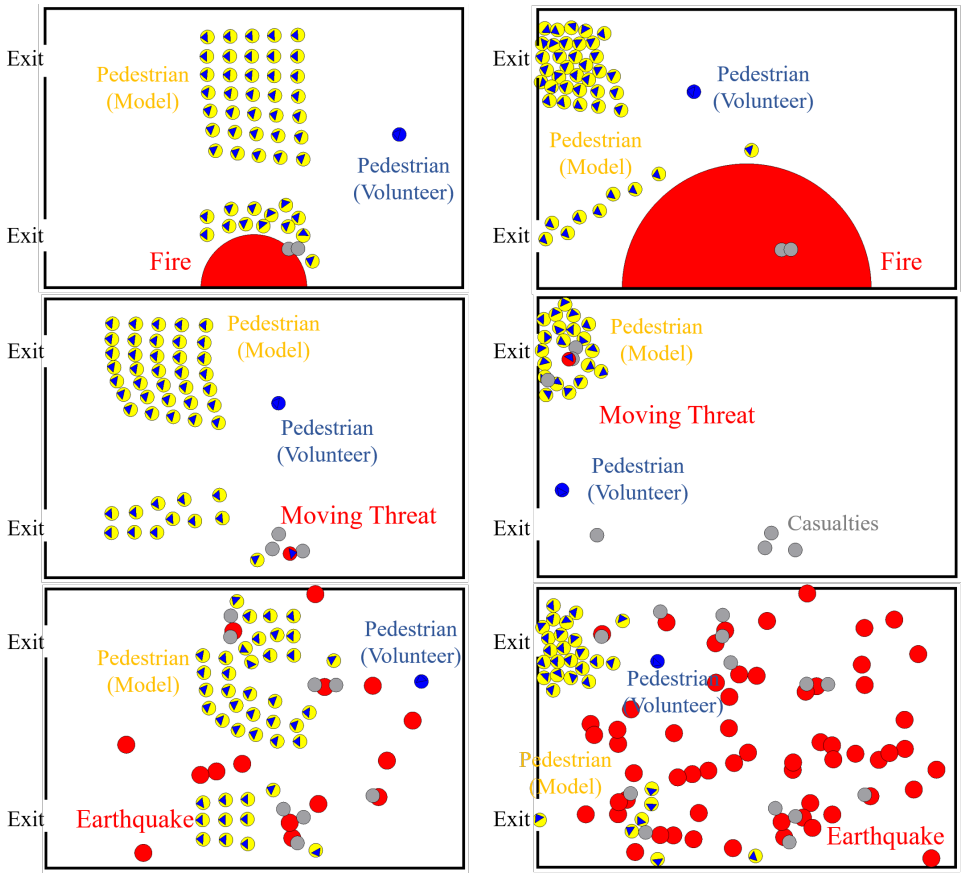

Figure 1: Screenshots of the top-down view presented to participants under different threat

We placed 50 NPCs in front of the participants, with 30 NPCs in the upper area choosing to evacuate through the upper-left exit, while the remaining 20 NPCs chose the lower-left exit. Throughout the movement process, the NPCs did not change their exit choices.

Each participant experienced one of eight possible experimental conditions. These experimental conditions were the three shown in Figure 1 with different threats and unbalanced exit usage by NPCs, plus a control condition where no threat was simulated. To account for possible top-down preferences of participants, we additionally tested the four mirrored conditions where the threat was initially positioned at the top of the display, and the larger proportion of NPCs moved towards the lower exit.

Data Collection: During the experiment, we recorded the movement trajectories of the participants, NPCs, threats, and each mouse click event in which a participant changed the location of the pedestrian's movement target.

Analysis Method

Since the exit closer to the threat has better congestion conditions during the experiment, we assume that by recruiting a sufficient number of participants, we can determine the proportion of pedestrians choosing the upper and lower exits under the three different threats.

First, we propose the hypothesis that different threats do not have a significant impact on pedestrians' exit choice. That is to say that different threats do not significantly alter the proportion of pedestrians choosing the upper or lower exit. Hypothesis testing will be conducted to address this question. If the hypothesis is rejected, we will further analyze the specific impact of different threats.

Additionally, by analyzing the participants' movement trajectories and expected position data, we aim to observe different pedestrian behaviors.

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