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Influence of Group Size and Group Composition on the adhered Distance Headway

Dorine Duives[a], Winnie Daamen[a], Serge Hoogendoorn[a]*

Delft University of Technology, 2628 CN Delft, The Netherlands

Abstract

Research into the influence of groups on pedestrian flow dynamics has been limited. Previous research found that group size influences the walking velocity of pedestrians within the group and as such the capacity the pedestrian infrastructure. This paper's aim is to provide quantitative insights into the influence of group size and composition of demographic characteristics on the distance headway pedestrians adhere to with respect to respectively other groups and other individuals within their own group, during bi-directional crowd movements. It is concluded that the composition of age and genders within a group, as well as the total size of the group influences also the distance headway pedestrians adhere during large crowd movements. As such, the presence of groups changes the dynamics of the crowd movements. This can result in a decrease of the capacity of the infrastructure.

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1. Introduction

Research into pedestrian movement dynamics has developed rapidly over the last decades. Many researchers have empirically studied the movement of individual pedestrians. The influence of personal characteristics such as age (a.o. Navin and Wheeler (1969), Henderson (1971), Bohannon (2004)), gender (a.o. Henderson (1971)), and culture (a.o. Tanariboon et al. (1991), Koushki (1988)) on the walking velocity of individual pedestrians has been

* Corresponding author. Tel.: +31 (0)15 2786325; fax: +31 (0)15 2783179.
E-mail address: d.c.duives@tudelft.nl

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studied in great detail. It is found that these characteristics influence the walking velocity of individual pedestrians severely.

Pedestrians do, however, not always move as singular entities. Especially during leisure activities pedestrians move in groups. Several studies found that the presence of groups during crowd movements influences the capacity of the infrastructure severely (a.o. Moussaid et al. (2010), Gorrini et al. (2013)). Yet, research focusing on the manner in which the presence of groups in a crowd influences the crowd's movement dynamics has been limited. Moreover, the research that has been done is mainly focused on the way in which the lay-out of groups influences the macroscopic flow variables. Improved insights into the influence of groups on the capacity are needed in order to improve the assessment, prediction and management of crowd movements.

In order to understand the influence of groups on the movement dynamics of the individual, a more in-depth quantitative analysis of their movements is necessary. Previous research has indicated that the demographic characteristics of the individual and group size affected the walking velocity of an individual. To see whether also the distance headway of pedestrians is affected by these characteristics, this paper aims to provide quantitative insights into the influence of the group size and the composition of groups on the minimum distance headways adhered by pedestrians within a group with respect to other groups and other individuals within their own group. In order to do so empirical trajectory data sets featuring the movement dynamics of groups of pedestrians are analyzed.

This study concluded that the composition of age and gender within a group, as well as the size of the group do not only affect the walking velocity. As a consequence, the presence of groups changes the dynamics of the crowd movements. Due to the occurrence of 'clogs', flow breakdown is expected at lower average densities for crowd movements with groups present than without groups. The presence of groups might therefore result in an additional decrease of the capacity of the infrastructure, on top of the decrease caused by the decrease in walking velocity.

The paper starts with an introduction of the used trajectory data sets in section 2. A description of the case study, the methodology of recording the video sequences and the transformation of the video sequences into trajectory data is provided in this section. Next, section 3 elaborates on the measures used to quantify the influence of the factors on pedestrian movement dynamics. Both the computation method of the walking velocity and minimum distance headway are elaborated upon. Also the method of identification of the demographic characteristics of the pedestrians is mentioned. The analysis results are presented in section 4. First the trends found in the data set with respect to individual pedestrians are reviewed. Accordingly, the trends specifically relating to group size and group composition are mentioned. This paper finishes with the discussion and some conclusion in section 5.

2. Case study and data sets

An empirical case study was used to study the influence of groups on the microscopic movement characteristics of pedestrians. There was sought for a case study that contained a bi-directional flow situation, which is generally seen as the most simple form of interaction between pedestrians, during which groups could be clearly identified. The Coronation of the new king in the Netherlands provided a good opportunity to capture crowd movement data featuring pedestrians leisurely walking in groups through a populated corridor. During Coronation Day on the 27th of April 2013, 700,000 visitors assembled in the city center of Amsterdam to take part in the festivities. During the day, the bi-directional crowd movements were studied on the Museumbrug. Figure 1 depicts an aerial view of the bridge. On the bridge a bi-directional flow of pedestrian arose from and to the Museumplein. Many pedestrians walked around in groups. Several cyclists crossed the bridge amidst the pedestrian crowd. Also some carts, mopeds and vehicles were found to be present on the bridge during the day, though very infrequent.

The movement of the pedestrians across the bridge has been monitored by 2 Multi-camera Stand Alone Video Installation (McSAVIs) during a large part of the day (10.00-18.00 hours). The installations are designed to record videos during large-scale pedestrian events within or near moving crowds. Due to its limited size, a McSAVI does not provide any hindrance to the movement of pedestrians, nor does it influence flow dynamics because of distraction as pedestrians are completely unaware of being studied. The video installation recorded from a height of 8.5 m. The size of the capture area was approximately 13 x 13 meters. As a result of the high vantage point of the cameras, the occlusion of pedestrians within the video is limited. The location of the McSAVIs is indicated in figure 1. The capturing rate of the cameras was 8 fps. This is quite low compared to ordinary cameras, but high enough to assess the trajectories of all pedestrians when considering the low walking velocities of pedestrians.