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# Exploring the effect of occupancy information on passengers' behaviour change to relieve train crowding

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**Abstract**

Alleviation of train overcrowding could have a positive impact on passengers' rail travel experience by reducing passengers' psychological stress and discomfort, and enhancing a sense of control. Overcrowding can be thought to be inevitable due to an increase in number of passengers, however it needs to be managed effectively because it is an undesirable situation especially for frequent passengers. Therefore, this project aims to develop strategies for moderating the issues of overcrowding by examining the effects of occupancy information developed to promote changes in passengers' behaviour. This will be achieved in the following ways: first, passengers' decision making in relation to positioning and selecting a carriage to board on the platform will be investigated through participant observation; second, factors influencing the decision will be identified, and verified in an online questionnaire study; finally, the effectiveness of designed occupancy information will be examined by measuring the participants' intentions to move to board empty carriages using hypothetical travel scenarios of a commuter, and a leisure traveller. The questionnaire data was gathered from 119 participants. The results demonstrated that the majority of the respondents thought the occupancy information was helpful (91%), and reported that they were willing to move to board a less occupied carriage if they had access to this type of information (95%). Moreover, the information was a significant predictor of their decision to move to board emptier carriages in both scenarios in estimated ordinal logistic regression models. The respondents reported that additional information is needed to support wayfinding on the platform to better locate the empty carriages.



*Keywords:* Occupancy information; passenger crowding; behaviour change; passenger positioning; choice of carriage

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## 1. Introduction

A wide range of efforts have been made to enhance railway infrastructure to better accommodate a growing number of passengers to moderate issues regarding overcrowding. These include constructing and modernising tracks, stations, and facilities to provide extra trains and seats (Network Rail, 2017). Despite these efforts, overcrowding is seen as unavoidable due to high concentrations of passengers travelling in short periods of time, especially at peak hours (Toriumi et al., 2014).

Overcrowding negatively affects passengers' experience of public transport (PT) use and the level of satisfaction (Passenger demand forecasting council (PDFC), 2017). The impacts are increased arousal of anxiety/stress and fatigue, perceptions of risk to personal security and safety, perceptions of invasion of privacy, lowered productivity while working, and poor usage of time during the travel, a close distance from other passengers (Tirachini et al., 2013; Haywood et al., 2017), and reduced physical comfort (Pel et al., 2014).

Overcrowding induces passengers' behavioural reactions. It Influences their pre-trip or en-route travel decisions, for example, they modify route choice to avoid delay from overcrowding and crowding itself (Kim et al., 2015). Further, they adjust departing time, choose alternative lines or stations, upgrade to first class, wait for less busy services, wait near the carriage doors, and move on the platform to get on a less occupied carriage (Pel et al., 2014; PDFC, 2017).

This study particularly focuses on passengers' reaction associated with choice of carriage on the platform because it benefits both passengers and service providers. For passengers, it neither requires amendment of their planned schedule, nor incurs additional cost accompanied by changes in their decisions. For service providers, more even passenger distribution across carriages could be helpful to minimise the vehicle dwell time (Transportation Research Board, 2003).

Controlling passengers' behaviour is discussed as one of the measures to spread passengers more equally across carriages when uneven distributions are problematic (Kim et al., 2014). This shows the potential effectiveness of occupancy information as a method to support changes in passengers' behaviour by informing them about carriage occupancy levels. This could be effective when informed passengers choose less busy ones especially when they pursue on-board comfort by getting a seat or more space (Hirsch and Thompson, 2014).

There have been related trials to investigate passenger' decision making during rail travel which is linked to behaviour change as a result of provision of information (Ahn et al., 2016; Preston et al., 2017; Fukusawa et al., 2012; Zhang et al., 2017). In the studies, the potential that information can stimulate behaviour change has been mentioned however, what has rarely been discussed is the effect of the information alongside the effects of additional factors associated with the decision making. It needs to be further clarified because multiple factors are involved in passengers' choice of carriage, and position on the platform (Kim et al., 2014). Further, passengers' actual behaviour change promoted by occupancy information on the platform was lower than perceived usefulness of the information (Zhang et al., 2017). This shows the necessity to consider the effects of additional factors alongside the effect of occupancy information when investigating passengers' decision making in relation to carriage selection.

Factors affecting decision making have been addressed in the relevant literature as follows: locations of entrance and exit (Lee et al., 2018; Rail Safety Standards Board (RSSB), 2018; Kim et al., 2014), position of seats, shape and size of baggage, size of platforms (RSSB, 2018), layout of platforms, length of trains (Kim et al., 2014), built environment, such as carriage and platform design (Hirsch and Thompson, 2014), carriage occupancy, and distance between platform entry and train doors (Lee et al., 2018).

This study aims to identify and confirm the effects of occupancy information in conjunction with the influences of certain factors on passengers' behaviour change whilst waiting on the platform for two hypothetical travel scenarios. In addition, the influence of key factors (occupancy information, distance to carriage, level of platform crowding, and exit information) are examined in ordinal logistic regression models. Behavioural intentions were assessed because they are a significant factor which leads to behaviour change according to the Theory of Reasoned Action. This theory demonstrates "how much of an effort they are planning to exert" to perform the behaviour. Behaviour changes are more likely to be conducted when the intention is higher (Ajzen, 1991). In this paper, potential changes in passengers' behaviour are explored regarding selection of carriage and positioning on the platform. This provides insights which enable to identify how occupancy information can be tailored to increase passengers' in-vehicle comfort by promoting them to select and board less occupied carriages. Moreover it extends the existing literature by investigating the influences of the information in conjunction with previously defined factors affecting passengers' decision in logistic regression models.

The remainder of the paper is organised as follows. In section 2, relevant studies are reviewed about provision of occupancy information and its impact on passengers. In section 3, methodology is discussed which comprises two phases: exploratory and descriptive phases. In section 4, result and discussions are delineated in two sections. First, participant observations were conducted to identify passengers' behaviours regarding waiting positions and constraints of moving along the platform. Second, a questionnaire study which examines the effect of designed occupancy information, and the impacts of factors affecting passengers' choice of carriage and intentions to board emptier carriages are explained. In section 5, concluding remarks and limitations are addressed.

## 2. Literature review

A number of attempts have been made to help spread passengers more evenly across carriages. Occupancy information has been used as a method to promote behaviour change by intervening in decision making regarding selection of carriage on the platform. Nuzzolo et al. (2016) argue that on-board crowding information can benefit passengers to make better decisions about times of departure, stops and runs for boarding especially in crowded conditions. In their study about development and application of a mesoscopic transit model, the simulation results presented that the occupancy information had a positive effect on reducing passengers' "fail-to-board" events. Further, passengers were less likely to skip severely occupied runs. Drabicki et al. (2017)'s simulation study results examining the effects of real-time crowding information in PT systems reveal that the effects are associated with certain factors. They are network congestion level, passengers' behaviours, penetration rate of the information– how ubiquitous the access to the information is, and type of information provision – whether it is smoothed over recent runs or instantaneously captured based on the latest run. Ahn et al. (2016)'s simulation study results demonstrate that carriage occupancy information has a positive impact on passengers' decision making process which led to more even passenger distribution on the platform. Furthermore, the average numbers of boarding passengers per door were more equal when the information was supplied. This was contrasted with the situation that passengers were waiting near the platform entry when the information was not given. Moreover, their survey results present that the information had a positive impact on the participants' intentions to move along the platform, and to reposition themselves on the platform to board emptier carriages. Preston et al. (2017)'s confirm that the respondents intended to wait longer when they were informed about seat availability and levels of occupancy of the next arriving train through the findings of a stated preference survey findings. Fukusawa et al. (2012) investigate changes in passengers' tendency in selection of train as a result of provision of information about train arrival times and levels of crowdedness. The participants tended to choose one train before they were exposed to the information, however they chose several trains according to their needs after the information intervention. Kim et al. (2009) examine the effects of real-time bus occupancy information on users. The results show that the participants were more likely to board an arriving vehicle when they were informed that there were available seats. On the contrary, they were less likely to get on when the level of crowdedness was higher. Zhang et al. (2017)'s Stockholm metro pilot study explores the effectiveness of provision of real-time occupancy information. The findings represent that the information had a significant positive impact on more equal passenger distribution on carriages, and had a downstream moderating impact on in-vehicle crowding. Interestingly, the positive consequences were found, however the extent of the observed changes was smaller than the extent that the participants appreciated the usefulness of the information. The discrepancy might have resided in differing values that they pursue in rail travel. For example, passengers would have selected a carriage closest to exit at the station at destination when they prioritised minimisation of walking distance to expedite their journey.

## 3. Methodology

This study was designed to answer a research question formulated as follows: 'How the designed occupancy information influence passengers' decision making about choice of carriage and behavioural intentions to move along the platform, and what factors influence the decision?'. It consists of three phases as shown in Table 1.

Table 1. Research framework

| Phase 1: Literature review | |
|---|---|
| Purpose | To review literature regarding passengers' response to occupancy information, and factors affecting their choice of carriage |

| Phase 2: Exploratory phase | |
|---|---|
| Purpose | To understand about passengers' waiting behaviours on the platform including passenger positioning and carriage selection |
| Data collection method | On-site participant observation |

| Phase 3: Descriptive phase | |
|---|---|
| Purpose | To investigate potential behavioural reactions to occupancy information<br>To identify and confirm factors affecting their decision to move |
| Data collection method | Questionnaire including close and open ended questions |
| Data analysis method | Quantitative data<br>- Descriptive analysis: Frequencies<br>- Inferential analysis: Ordinal logistic regression<br>Qualitative data: Coding and theming |

In the first phase, studies about provision of occupancy information and its effects on passengers' behaviour on the platform and factors influencing their travel decision were reviewed. In the second phase, two participant observation studies were undertaken to have an understanding about passengers' decision making for positioning themselves, and choice of carriage on the platform. In addition, the possibility to stimulate passengers' behaviour change by providing information was explored. This method was chosen as it allows researchers to elicit meanings from passengers' behaviours by being immersed in the actual setting, and to gather first-hand experience of the service as a traveller (Bryman, 2014). Participant observation is also an appropriate method to discover what is going on by watching and listening to individuals. The insights gathered from the studies were utilised to design a follow-on questionnaire (Robson and McCartan, 2016). In the third phase, an online questionnaire was conducted to identify the effects of designed occupancy information by rating participants' intention to move to get on less occupied carriages. Furthermore, the influences of pre-defined factors along with the effects of occupancy information were verified. Motives affecting passengers' decision to move were further inquired through open-ended responses. The method was chosen because it has benefits, such as cost-effectiveness, fast return, and minimised geographical constraints (Robson and McCartan, 2016; Bryman, 2014). A key benefit of the method was that it enabled access to participants from a wider range of regions more effectively, such as rail user groups scattered across the UK.

Open-ended responses were analysed following the Braun and Clarke's guidance for six-phase thematic analysis (Braun and Clarke, 2006). First, the collected data was read thoroughly to familiarise with the content. Tentative thoughts for codes, patterns, and themes were written down in the process. Responses repeatedly appeared were paid attention to because identifying recurrent patterns and consistencies of actions is one of the major goals of researchers (Saldaña, 2013). In the process, each piece of information was colour coded to be easily distinguished (Burnard, 1991). Second, initial codes were identified from the data (Braun and Clarke, 2006). Codes are defined as "a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data" (Saldaña, 2013). Third, the codes were reviewed carefully, and those which represented similarities in meaning were themed. Fourth, the candidate themes were refined which described the participants' decision making for values pursued in rail travel (Braun and Clarke, 2006).

## 4. Result and discussions

### *4.1. Exploratory phase*

Two observation studies were conducted to understand passengers' behaviour shaped by the environment on the platform. In particular, passengers' behavioural patterns were observed linked to positioning and selecting a carriage on the platform considering the effects of interaction with other passengers, the staff, and physical/technical environment that can influence the behaviour (Edvardsson and Olsson, 1996). Also, constraints to finding and boarding required carriage were identified. This will be beneficial when defining passengers' information needs which arise from a gap between the current and required levels of knowledge in a difficult situation (Nicholas and Herman, 2010).

The first observation was conducted at London Victoria, Gatwick Airport, Brighton stations on the 28th of March, 2018. The second observation was made at Gatwick Airport station at Platform 4 during the morning peak hours on the 9th of May, 2018 whose scope was focused. In the second observation, Gatwick Airport station was chosen because in-vehicle crowding of trains starting from Brighton tends to be higher than the rest of the intermediate stations between Brighton and London Victoria. Platform 4 was selected because it was the platform where the trains called at in the morning. The time of day was chosen to see passengers' behaviour in crowded conditions when uneven on-platform and in-vehicle passenger distributions were more problematic.

- Characteristics of passengers

Two main types of passengers were observed – international travellers going to, or returning from trips carrying heavy luggage, and commuters travelling to London. It seemed that levels of knowledge gained from prior travel experiences could vary significantly between the two groups, such as locations of platform entry, exit, travel direction of trains, order and stopping positions of carriages, and carriage occupancy patterns of the next coming train. Additionally, it was seen it could be difficult for novice passengers to identify their location on the platform. They should be better supported because more informed passengers can make a better decision about "how, when and how to travel" (Farag and Lyons, 2008). In this sense, provision of directional information seemed necessary to assist novice passengers to identify where they are located on the platform, and how to get to the points – facilities or required carriages – in relation to their positions on the platform (Darken and Peterson, 2014).

- Passenger positioning patterns

On-platform crowding patterns were observed on Platform 4. Passengers entered the platform using the escalator/stairs and tended to wait near the entry point rather than going towards the both ends of the platform. It seems challenging to spread passengers along the platform unless passengers perceive the benefits of moving are bigger than the expected penalty of not moving, e.g. securing a seat by moving versus not being able to sit when staying.

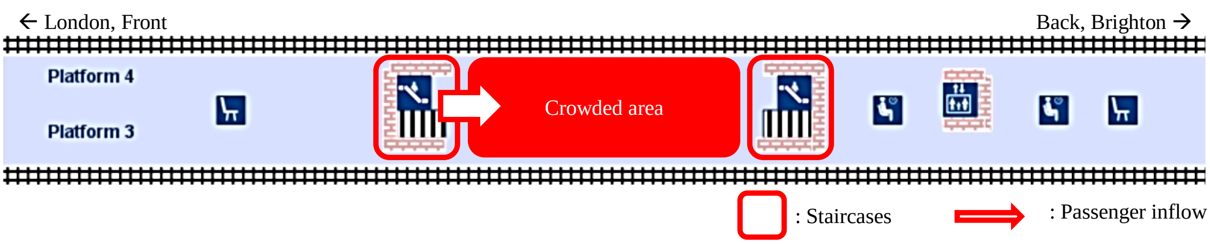



Fig. 1. Gatwick Airport station platform diagram (National Rail, 2018)


Fig. 2. Most crowded area between the walls around the stairs and the escalator (Left and right)
Number of passengers/m$^2$ – approx. 0.44 person/m$^2$ (Left)

- Factors affecting passenger movement and positioning

A number of factors influencing passenger positioning on the platform were identified from the observation studies concerned with their decisions about moving along the platform.

**Physical conditions**: Narrowness, curves, and crowdedness of the platform – these made it hard to assess the situation on the whole platform, and to identify all positions of platform entry. Thus passengers were prone to stay near the platform entry. Uncovered areas on the platform – passengers would not want to wait outside covered areas in bad weather conditions.

**Fellow passengers**: Passengers seemed to feel more comfortable to wait near where existing fellow passengers were standing.

**Company and luggage**: Company during travel, and accompanying luggage could be barriers of moving especially when the platform is crowded (Shah et al., 2013).

**Uncertainty about their location**: Passengers' sense of direction could be compromised when they are unable to identify their own location on the platform. This cognitive gap might be complemented by provision of information, such as directional signs, information displays (RSSB, 2018).

**Uncertainty about benefits of moving**: Passengers were less motivated to reposition on the platform unless they were certain that their needs could be met by moving along. The benefits could be acquiring a seat, minimising a walking distance at destination station (Kim et al., 2014).

Passengers should be informed to a certain extent to decide to move or not on the platform whether their information seeking is passive or active (Ramirez et al., 2002). Information might be able to support their decision making process by increasing positive effects, or decreasing negative effects of the identified factors.

### *4.2. Descriptive phase*

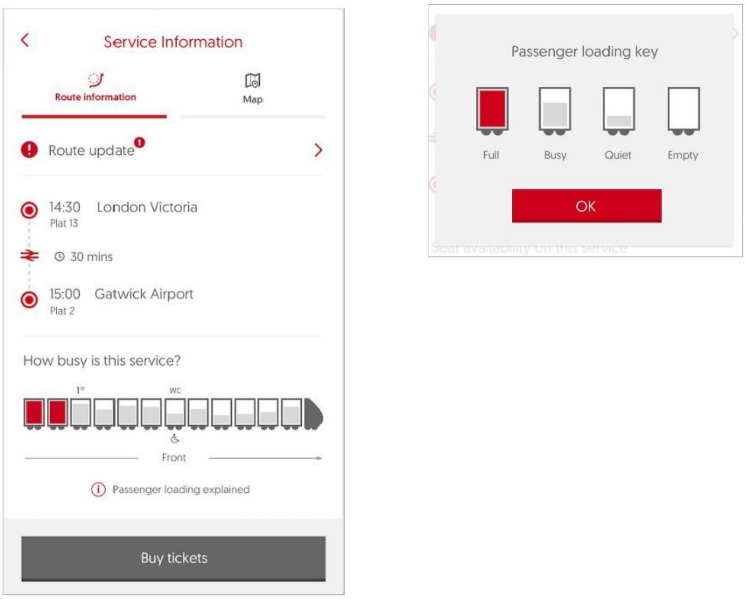
- Purpose

This questionnaire study aims to investigate the effects of designed carriage occupancy information delivered on a mobile App on passengers' behavioural intentions to move to board a less crowded carriage. It also attempts to identify and verify factors affecting passengers' decision making in relation to positioning and selecting a carriage to board on the platform.

- Structure of the questionnaire

The questionnaire is comprised of three sections: first, demographic questions, second, questions about designed occupancy information, and third, questions about two travel scenarios asking respondents' intention to move to board less occupied carriages according to the provided occupancy information.

In the second section, responses to the carriage occupancy information were investigated. For example, the level of likelihood to move to board a less busy carriage, perceived helpfulness and reliability of the information were asked. Open-ended questions were included to allow the respondents to describe their own thoughts related to the decision making.




A. Service information screen B. Passenger loading key

Fig. 3. Images of the mobile App

In the third section, respondents were asked to rate their responses to two different travel scenarios by estimating their intention to move to board less occupied carriages. In the scenarios, the route, departure time, travel duration, and platform/train situations were suggested as the same. However, the only difference was the purpose of trips, and the amounts of luggage.

In the two scenarios, 1) route: Gatwick Airport to London Victoria, calling at London Victoria only, 2) departure time: 08.20am, 3) Journey duration: 30 minutes were set as the same. Also, crowdedness of the platform (see Fig. 4) and the platform diagram (see Fig. 5) were given the same. The differences were as follows: 1) trip purposes: commute and leisure travel, 2) the amount of luggage the travellers were carrying: 1 briefcase and 2 suitcases.

Participants' intentions to move to carriages 6 (23 meters away), 9 (84 meters away), and 12 (140 meters away) from the point marked as "You are here" in the diagram which is closest from carriage 5 (see Fig. 5). A five-point Likert scale was used ranging from highly unlikely to highly likely including neutral response in the middle was used to measure the intentions.

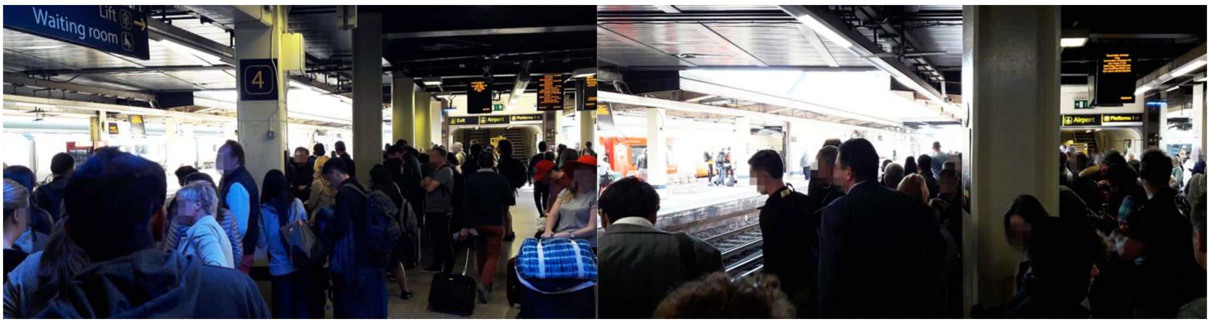



Fig. 4. Views from the point where the traveller entered the platform in the scenarios


Fig. 5. Platform diagram

Fig. 6. Silhouettes of a commuter (Left) and leisure traveller (Right) in the scenarios

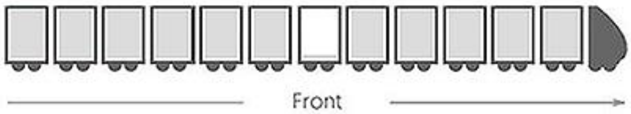



Fig. 7. An example of train with visualised occupancy in the questions

- Questionnaire development and ethical approval

The questionnaire form was created on iSurvey a survey generation and research platform available for members of the University of Southampton. The study was approved by the Ethics Committee of the Faculty of Engineering and the Environment on the 8th of June, 2018 (Submission ID: 41385).

- Participant recruitment

Participants were recruited on various online platforms. The questionnaire form was posted on iSurvey, and distributed on SUSSED News, the University's intranet, and the University's Student Communication Facebook page. An official survey invitation email was sent to members of the Faculty of Engineering and the Environment, and the Estate and Facilities team of the University. Furthermore, a national list of the UK rail user groups was gathered on the RailFuture website, an independent organisation for better rail services. From the list, twenty seven groups were contacted by email, and their intentions to circulate the questionnaire to their members were asked. Three of the approached organisations: RailFuture, Tonbridge Line Commuters, and St Leonards and Hastings Rail Improvement distributed the form on the websites or twitter pages.

- Data collection and analysis

The period of data collection was from the 8th of June to 4th of July, 2018. On the survey platform, 1,201 attempts were recorded however they included robotic activations, and mouse clicks made by viewers which simply opened the questionnaire page. Only completed forms were included in data analysis, and the data was analysed using IBM SPSS Statistics 24.

- Sample

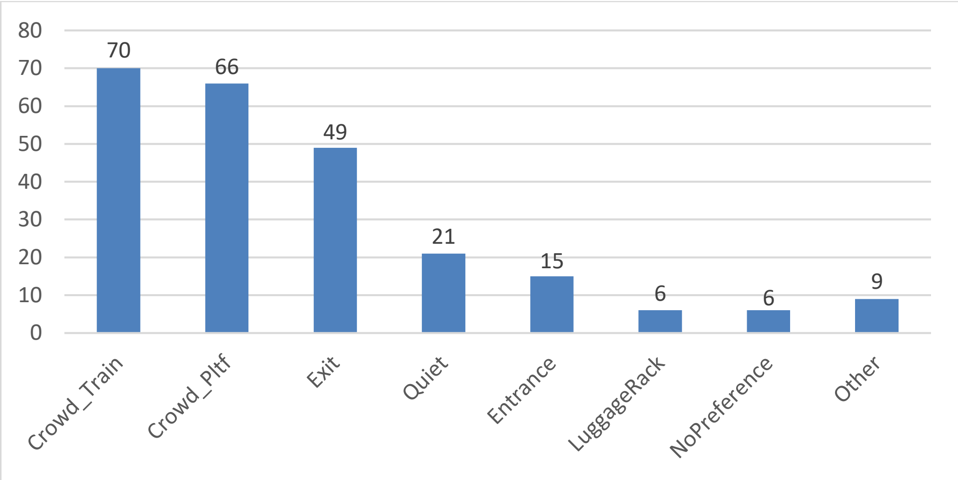
In total, 119 forms were collected from 70 males and 47 females. 2 missing responses were found. Male respondents represented a greater portion of the sample because more rail travels were made by male passengers in all the age groups apart from the age bracket above 60 years (Department of Transport, 2017). In addition, more service rail trips were made by male users (24 trips) than female users (18 trips) on average per year (Department for Transport, 2018).

Age distributions were as follows: 18-24 (N=23, 19.3%); 25-34 (N=49, 41.2%); 35-44 (N=25, 21.0%); 45-54 (N=9, 7.6%); 55-64 (N=8, 6.7%); 65-74 (N=4, 3.4%); missing (N=1, 0.8%). The biggest portion of the participants was positioned between the age of 25-34, followed by 35-44, and 18-24. Participants aged between 25 and 44 represent a greater portion of the sample because the National Travel Survey data shows the biggest number of rail trips were made by male passengers aged between 30 and 39 (Department for Transport, 2018a).

43 (36.1%) participants responded that they have used rail services from Gatwick Airport to London Victoria, and 75 (63%) participants have not. One (0.8%) missing response was included.

Frequency of use of the services from Gatwick Airport to London Victoria was asked among the 43 users who have the experience of using the services. The frequencies were measured as follows: Less than once per month (N=35, 29.4%); Less than once per week (N=3, 2.5%); 1-4 days per week (N=3, 2.5%); other (N=2, 1.7%). The frequent passengers of the services might have knowledge on the route and location of entrance at Gatwick Airport station, and exit at London Victoria station achieved from the actual travel experiences.

- Factors considered in selection of carriage

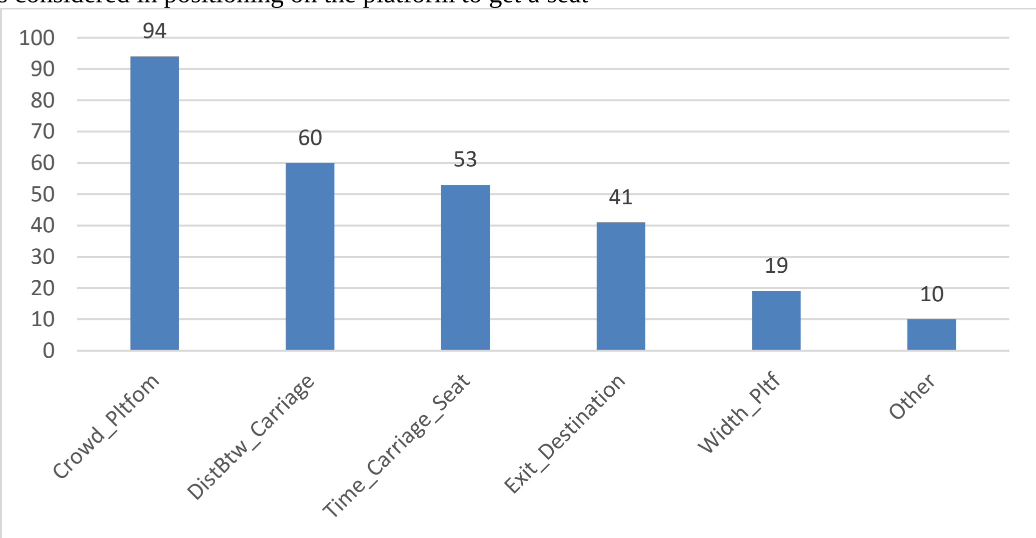



Y axis = Number of responses, N of respondents =119, N of total responses = 242, MTP = Multiple

Fig. 8. Factors considered in selection of carriage (Multiple-choice responses)

The respondents were inclined to choose a carriage to board by seeing how crowded the train is, followed by how crowded the platform is. The level of crowdedness in train cannot be observed until the train arrives at the platform. This implies that passengers may not have enough time to move to board an empty carriage if it cannot be reached within the train's stopping time at the platform. Thus occupancy information could be useful to resolve passengers' information needs about how full the carriages in the next train will be, and help them decide to move before the train arrives. Location of entrance was not rated as highly as expected unlike the findings from the observation study, and Kim et al.'s (2014) study findings. This implies that when passengers choose a carriage intentionally, they value other factors – on-board comfort, rapid egress at destination station – more than minimisation of walking distance at origin.

- Factors considered in positioning on the platform to get a seat




Y axis = Number of responses, N of respondents = 119, N of responses = 277

Fig. 9. Factors considered in positioning on the platform to get a seat (Multiple-choice responses)

Platform crowding was rated as the most considered factor to position themselves on the platform to get a seat in the next train. This may explain that the level of platform crowding can be a source of information which tells how filled the carriages in the next train will be. Nevertheless, this information may not be reliable when there are travellers waiting for different services which depart at the same platform. Distance between their position and the carriage in which they can find a seat was recorded as the second important factor followed by the time taken to reach it. Once they have a goal to get a seat, they see how busy the platform is, and consider how practical it is to reach the carriage by gauging the distance and time. Location of exit was measured as a less important factor when they value being able to sit.

- Importance of getting a seat

The majority of the participants (N=96, 81.4%) responded that getting a seat is very important (N=51, 42.9%), or important (N=45, 37.8%). The rest of the answers were neutral (N=14, 11.8%), unimportant (N=3, 2.5%), very unimportant (N=5, 4.2%), and 1 missing response. The result was in line with previous findings about valuation of seat availability in train travels (Schmöcker et al., 2011, Thompson et al., 2012).

- Willingness to board a less busy carriage according to occupancy information

As a response to the suggested occupancy information (see Fig. 3), a considerable portion of the respondents (N=111, 93.3%) answered they were highly likely (N=68, 57.1%) or likely (N=43, 36.1%) to try to board a less busy carriage. The rest of the answers were neutral (N=2, 1.7%), unlikely (N=4, 3.4%), and highly unlikely (N=2, 1.7%).

- Willingness to move along the platform to board a less busy carriage according to occupancy information

As a response to the proposed occupancy information (see Fig. 3), a considerable portion of the respondents (N=113, 95%) stated that they are highly likely (N=66, 55.5%) or likely (N=47, 39.5%) to move along the platform to be in the right position to easily board a less busy carriage. The remainder of the answers were neutral (N=3, 2.5%), unlikely (N=2, 1.7%), and highly unlikely (N=1, 0.8%).

- Helpfulness of occupancy information

Positive opinions about the information (see Fig. 3) were acquired. The majority of the participants (N=108, 90.8%) reported that the information was very helpful (N=50, 42%) or helpful (N=58, 48.7%). Neutral (N=8, 6.7%), not helpful (N=2, 1.7%), not at all helpful (N=1, 0.8%) answers were also found. Perceived helpfulness is one of the contributing factors of to measure the efficacy of a website (Sciamanna et al., 2002). The rated helpfulness may have a positive effect on willingness to accept the information service when launched.

- Reliability of occupancy information

The participants' opinions about reliability of the information varied eliciting a sizable number of don't know (N=27, 22.7%), and neutral responses (N=31, 26.1%). The remainder of the responses were rated as very reliable (N=1, 0.8%), reliable (N=38, 31.9%), unreliable (N=19, 16%), and very unreliable (N=3, 2.5%). When users have real experiences of comparing forecasted loading information and actual occupancy, the answers would show more distinct patterns.

- Additional information to find a less busy carriage

Possible responses were given in the question: train stopping points at platform, direction of train, carriage number. Both the a priori, and emergent issues were identified in the data analysis process (Swallow et al., 2003).

Table 2. List of identified codes and themes

| | Code | Type | Number of occurrences | Theme |
|---|---|---|---|---|
| **1** | Carriage numbers | A priori | 44 | Navigation |
| **2** | Train stopping points | A priori | 44 | |
| **3** | Travel direction | A priori | 20 | |
| **4** | Mixed information | Emergent | 5 | |
| **5** | Numbers of seats | Emergent | 13 | Quantified occupancy levels |
| **6** | Train facilities | Emergent | 14 | Fulfilment of on-board requirements |
| **7** | Train formation and platform information | Emergent | 13 | Positioning on-board |
| **8** | Exit information | Emergent | 3 | Quick exit |
| **9** | Other information | Emergent | 19 | Other |

Table 2 presents codes, numbers of occurrences, and themes developed based on the codes. The numbers of occurrences were counted because reporting the number of individual occurrence is suggested as a method to demonstrate prevalence (Braun and Clarke, 2006), Interpretations will be made based on the developed themes.

**Navigation**: The first four items were themed as navigation because the information was necessary to identify where travellers are on the platform in relation to the carriage they want to board. The mixed information means occurrences of one, or multiple of the elements shown in the question as the examples along with additional information mentioned by the respondents. Information about train stopping point was mentioned 44 times which included information about location of each carriage, and carriage stopping area. The responses contained two answers describing the difficulty in estimating where carriages will be stopped before a train arrives, and three responses about the need of marking locations of each carriage door on the platform or on the App. Additionally, the details of mixed information were as follows: the point of where the respondents are in relation to the train, carriage numbers marked on the platform that match carriage numbers on trains, and carriage numbers shown on the App, subdivided platform sections shown on the App, carriage stopping points in relation to the platform layout.

**Quantified occupancy levels**: Numbers of available or reserved seats were addressed in the sense that the information could be useful to find free seats more easily, and to avoid boarding carriages with more reserved seats. It can be judged that the respondents require certainty about probability to secure a seat to decide to move or not.

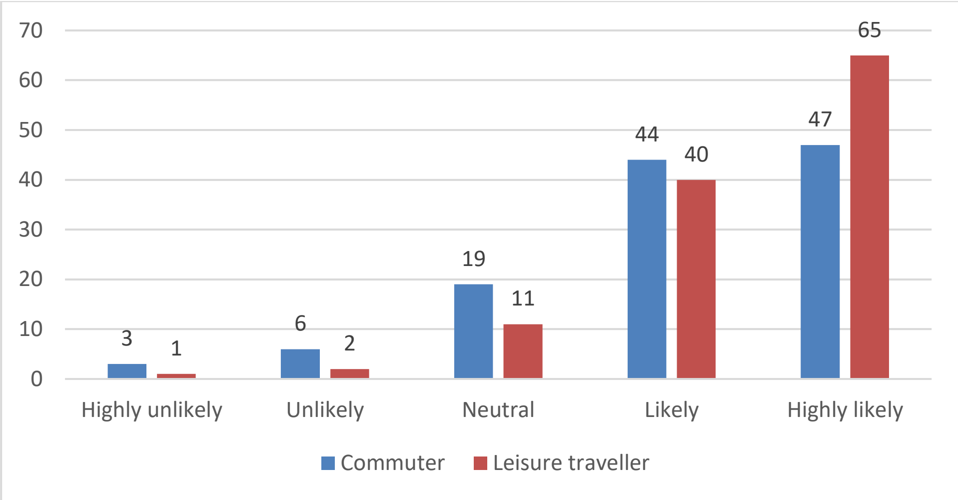
**Fulfilment of on-board requirements**: The responses were concerned with train facilities, such as locations of tables, charging points, bicycle storage, first class carriage, luggage racks, quite carriages, disabled or priority seating, accessible doors for wheelchair/trolleys/pushchairs, and single or double seat. These represent the respondents' divergent needs when travelling.

**Positioning on board**: Information about different lengths of trains and platforms, and train separation was mentioned. This information could be helpful to choose a carriage to complete a journey without repositioning while travelling.

**Quick exit**: The recorded frequency was low but exit information has been stated as a one of the most significant determinants for choosing a carriage which enables rapid egress at destination (Kim et al., 2014).

**Other**: Other types of information were reported 19 times. They included information about noise/temperature, numbers of people who will get off, and board at the next stop, occupancy information visualised in different colours or percentages, occupancy information delivered on display screens on the platform, reliability of the occupancy information, the sources used to generate the occupancy information, no intention to use the App but to walk through and find a seat, and a comment expressed a possible negative impact of the occupancy information which will encourage passengers to board, and fill up emptier carriages as a result, which may negate the intended purpose.

- Wanting to get a seat in the travel scenarios



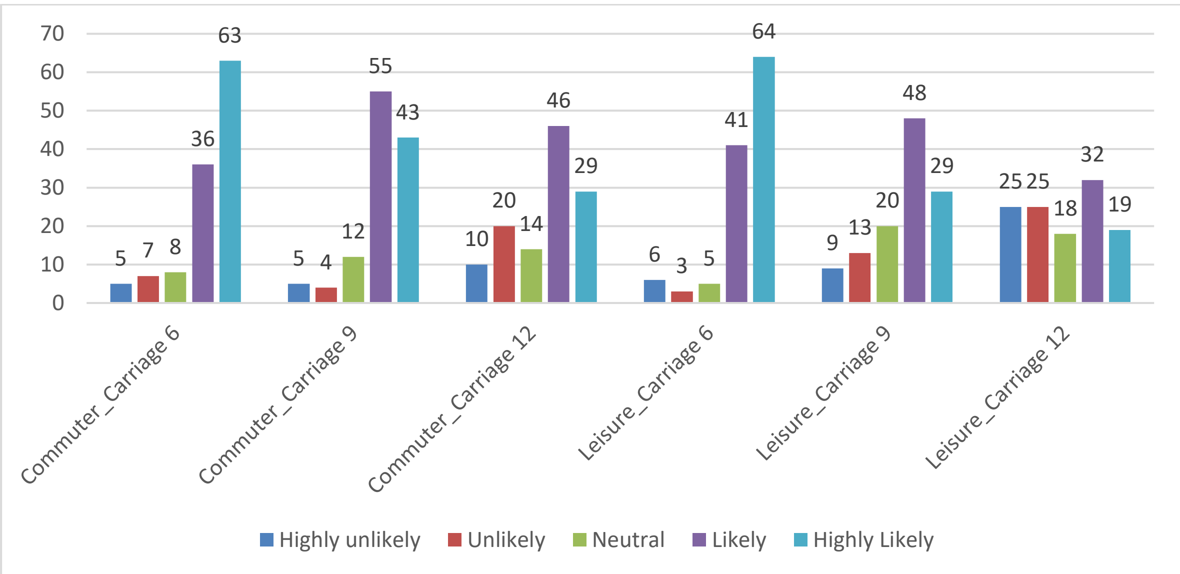

Y axis = Number of respondents

Fig. 10. Responses about wanting to get a seat in both scenarios

In general, a stronger want to get a seat is found in the responses from the leisure traveller's scenario. The want might result from fatigue induced by the physical demand they would be experiencing with carrying heavy suitcases.

- Intention to move to board specific carriages in the travel scenarios

Frequencies of the rated participants' intentions to move to board specific carriages in the two travel scenarios were investigated. In the questions, all the carriages were shown almost full apart from the specific carriages (carriage 6, 9, and 12) shown to be empty (see the example in Fig. 7).

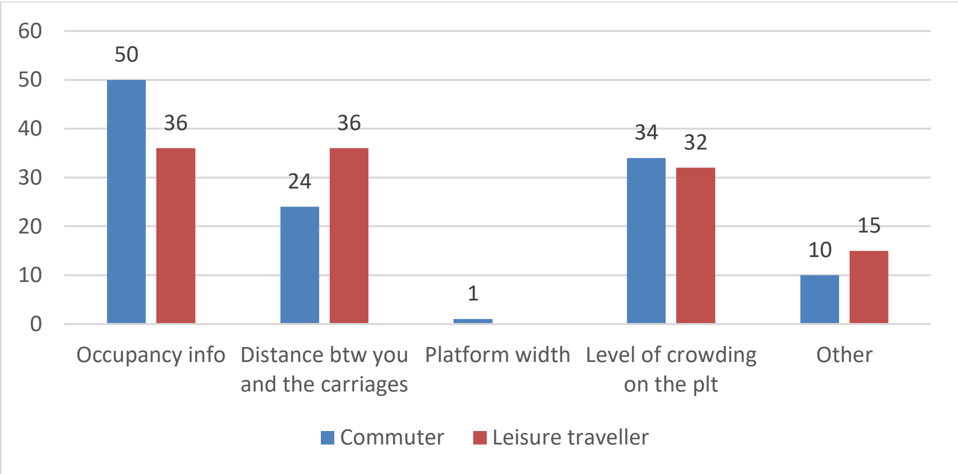



Y axis = Number of respondents

Fig. 11. Intentions to move to board carriage 6, 9, and 12 in the scenarios

The frequencies of highly likely responses show gradual decreases as the distances increased in the both scenarios. However, likely responses do not present this pattern in the both cases. The greater numbers of likely responses were rated about their intentions to move to board carriage 9 than those of the intentions to move to board 6 even the distance to carriage 6 was shorter. This implies that travellers would not want to get on middle carriages because they are usually busier than others (Karekla and Tyler, 2012). The frequencies of unlikely and highly unlikely responses show gradual increases as the distances increase apart from the unlikely response in the commuter's scenario but the difference was minor. Higher degrees of unlikely or highly unlikely responses were rated in the leisure traveller's scenario than those rated in the commuter's scenario. This could be interpreted that accompanying luggage is a barrier to moving along the platform.

- Most important factors affecting the decisions to move in the scenarios




Y axis = Number of respondents

Fig. 12. Most important factors for the decision to move

The responses explain that the participants were guided by the occupancy information in the both scenarios, however a greater number of responses was gathered in the commuter's scenario. It seems sensible to judge that the distance was less of an issue in the commuter's scenario because the commuter was seen to be able to move along the platform more easily. With respect to the answers from the leisure traveller's scenario, occupancy information and the distance were selected equally as important factors followed by the level of platform crowding. This may describe that the walking distance was considered more because of their limited mobility due to the luggage. The effects and significances of the factors are tested in ordinal logistic regression models in the following section.

- Testing the effects of the influencing factors

Ordinal logistic regression was applied to examine the effects of the factors on the participants' intentions to move to board specific carriages (carriage 6 – closest, 9 – middle, and 12 – furthest) according to the provided occupancy information. Ordinal logistic regression was used to analyse the data because the outcome variables have more than three ordered categories measured by ordinal scale (Gümüş et al., 2012; Das and Rahman, 2011; Bender and Grouven, 1997). The method has been used in the relevant studies discussing individuals' intentions and perceptions (Gümüş et al., 2012; Eboli and Mazzulla, 2009; Tzeng, 2002; Frangos et al., 2011)

Details of the tested models and variables are presented in Table 3.

Table 3. List of models and variables

| Model | Explanatory variable | Outcome variable | |
|---|---|---|---|
| | | Scenario | Intentions to move to board |
| 1 | 1) Distance to carriage<br>2) Occupancy information<br>3) Platform crowding | Commuter | Carriage 6 |
| 2 | | Leisure traveller | Carriage 6 |
| 3 | 1) Distance to carriage<br>2) Occupancy information | Commuter | Carriage 9 |
| 4 | | Leisure traveller | Carriage 9 |

| | | | |
|---|---|---|---|
| 5 | 3) Platform crowding<br>4) Exit information | Commuter | Carriage 12 |
| 6 | | Leisure traveller | Carriage 12 |

Six ordinal regression models were identified that included the chosen predictors and the intentions to move to board each specific carriage in both scenarios as outcomes. Exit information was contained in the models from 3 to 6. The reason is the location of exit at destination, London Victoria station is closest from the front carriage (carriage 1), which means that the distances are greater from carriages 9 and 12 to the exit from carriage 6. This may denote that the exit knowledge could be more influential in decisions to walk to carriage 9 and 12, as travellers attempt to minimise walking distance at destination station (Kim et al., 2014; RSSB, 2018). All six models produce a good model fit, with $p < 0.0001$ for models 1, 4, 5, and 6, $p < 0.001$ for model 3, and $p < 0.01$ for model 2. The significant p-values validate that the models with the independent variables explain better than the null models with no predictors (Liu and Koirala, 2012). The non-significant Pearson chi-square goodness-of-fit statistics ($p > 0.05$) demonstrate that the ordinal logistic regression models provide a good fit. The null hypothesis for this goodness-of-fit test is that the model fits the data well. The alternative hypothesis is that there is some (unspecific) problem with the fit, in other words a lack of fit. A small p-value is thus an indication that something is wrong with the model (Fagerland and Hosmer, 2017). Also the non-significant results for the test of parallel lines indicates fulfilment of the proportional odds assumption in that the null hypothesis that the slope coefficients are the same across response categories cannot be rejected (Frangos et al., 2011; O'Connell, 2006). In the regression analysis, the responses of the question asking the most important information for the decision making in the two travel scenarios were dummy coded. Marked responses were coded as 1, and unselected responses were coded as 0 (Field, 2009). The marked ones were assigned as reference variables. Occupancy information was a consistent significant factor in the assessed six ordinal logistic regression models. A summary of the results are shown in Table 4.

Table 4. Summary of ordinal logistic regression

| Model | Explanatory variable | Regression coefficient | Std. Error | Sig. | 95% Confidence Interval | | Odds ratio |
|---|---|---|---|---|---|---|---|
| | | | | | Lower bound | Upper bound | |
| 1 | Occupancy info | -1.592 | 0.638 | 0.013 | -2.842 | -0.341 | 4.914 |
| | Distance to carriage | -1.535 | 0.708 | 0.030 | -2.923 | -0.148 | 4.641 |
| 2 | Occupancy info | -1.628 | 0.612 | 0.008 | -2.829 | -0.428 | 5.094 |
| 3 | Occupancy info | -1.937 | 0.686 | 0.005 | -3.282 | -0.592 | 6.938 |
| 4 | Occupancy info | -2.057 | 0.639 | 0.001 | -3.309 | -0.805 | 7.822 |
| 5 | Occupancy info | -2.201 | 0.665 | 0.001 | -3.504 | -0.897 | 9.034 |
| 6 | Occupancy info | -2.424 | 0.627 | 0.000 | -3.654 | -1.195 | 11.261 |

*Note*: This table presents information of significant explanatory variables only. The parameter estimates that include all variables are added in the Appendix A.

The odds rations were identified as the ratio of the odds of intentions to move to board of the respondents who rated the occupancy information as the most important factor over the odds of the intentions of the respondents who did not rate the information was the most important factor. These were computed by taking the exponential of the absolute value of the regression coefficients. According to the model 1 testing result, the respondents who valued the information were 4.9 times more likely to move to board carriage 6 than those who did not. For model 5, where the distance to walk is longest, this increases to over 9 times.

The tendency of decrease in the coefficients as the distances increased could be surmised that the respondents' intention to move to carriages further distances away can be better accounted for by occupancy information. This can be interpreted that if the distances had mattered to the respondents considerably, they would not have intended to walk to the further carriages if they were not motivated by the information. The influence of the information seems to be strongest in the model 6, when the distance is longest in the leisure traveller's scenario. This describes that the information may be able to promote passengers to move longer distances.

The effect of distance on the intention to move to board carriage 6 in the commuter's scenario was also significant. A 1.535 increase ($p = 0.03$) in the intention was predicted when the respondents selected the distance as the most important factor. This elucidates that when the respondents valued shorter walking distance to carriage, they tended to choose the closest carriage. The impact of distance on the intention to move to board carriage 5 in the leisure traveller's scenario was not significant. However, the significance level of the impact was 0.079 that was close to the threshold level 0.05. It is interesting that the effect of knowledge about location of exit was not significant in the models 3-6. This is dissimilar to the findings from Kim et al.'s study (2014) which demonstrates that minimisation of walking distance at destination was the strongest predictor in selection of carriage. The disparity in findings might result from different reactions observed in different travel situations discussed in the present and the Kim et al.'s study – rail trips whose durations were 30 minutes with no stations between origin and destination, and metro trips in which travellers can board and alight at intermediate stations located at shorter intervals.

## 5. Conclusion and recommendations

This study took a strategic approach to contemplate relieving the issues of crowding in trains by encouraging passengers' behaviour change through provision of occupancy information. It was attained by understanding passengers' behaviour on the platform through participant observations. Factors affecting the behaviour regarding positioning and selecting a carriage were found: physical conditions, fellow passengers, company, accompanying luggage, and uncertainty about their location on the platform. In addition, it was achieved by examining passengers' intentions to board emptier carriages as a response to the suggested occupancy information in an online questionnaire study. 93.3 percent of the participants rated that they are highly likely or likely to try to board a less occupied carriage according to the suggested occupancy information. 95 percent of the respondents answered that they are highly likely or likely to be in the right position to board a less busy carriage. The positive responses to the information relating to their intentions to move supports the claim that occupancy information can be a facilitator to stimulate changes in passenger behaviour on the platform to reduce overcrowding in trains. The information was a significant predictor of the intentions to move to board less busy carriages in both travel scenarios according to the ordinal logistic regression model testing results. The findings present that occupancy information has potential to positively influence passengers' behaviour change. However, passengers' needs vary according to their trip purposes as found in open-ended responses, they want to select an optimum carriage to meet the requirements. Consequently, the occupancy information is likely to meet the needs for on-board comfort by increasing the possibility to secure a seat in the next train.

Occupancy information will be able to better support passengers' behaviour change when it can assist navigation on the platform as the need was expressed in open-ended responses. This could be achieved through provision of directional information, such as signage, information displays that guide train travel direction, and locations of carriages on the platform. In addition, it seems important to consider the level of passengers' mobility and the amount of luggage they are carrying when suggesting a route to a less busy carriage. For instance, passengers with heavy luggage whose mobility is temporarily limited would require information about where the closest lifts and escalators are to the carriage they intend to board. This would also be applied to physically less able passengers.

### *5.1. Limitations and future work*

Whilst the questionnaire included a sample size of 119, the results and interpretation would hold greater validity with a larger sample size. The rationale behind this argument is as follows: the responses regarding behavioural intentions to move along the platform to get a seat, factors influencing their choice of carriage on the platform, and perceived helpfulness of occupancy information demonstrated clear patterns. These exploratory findings will be able to contribute to developing more in-depth studies which further discuss the association between provision of occupancy information and behaviour change. Moreover, the participants' behavioural intentions were measured in the hypothetical travel scenarios. The platform conditions were presented on the two dimensional images with specified dimensions in the scenarios (e.g. platform width, length). The information may have not been sufficient for the respondents to envision the actual settings. This may negatively influence external validity related to how generalisable the results are (Pedersen et al., 2011; Saunders et al., 2009). Nevertheless, the main findings about the occupancy information as a predictor variable for the intentions to move along the platform to board a less occupied carriage in regression models were generally consistent with the prior study findings, thus the potential weakness may be compensated.

## Acknowledgements

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## Appendix A. Ordinal logistic regression parameter estimates of six models

### *A.1. Model 1*

**Parameter Estimates**

| | | Estimate | Std. Error | Wald | df | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower Bound | Upper Bound |
| Threshold | [Commute_Carriage6 = 1] | -5.366 | 1.360 | 15.577 | 1 | 0.000 | -8.031 | -2.701 |
| | [Commute_Carriage6 = 2] | -4.373 | 1.315 | 11.060 | 1 | 0.001 | -6.951 | -1.796 |
| | [Commute_Carriage6 = 3] | -3.711 | 1.299 | 8.155 | 1 | 0.004 | -6.257 | -1.164 |
| | [Commute_Carriage6 = 4] | -1.929 | 1.262 | 2.334 | 1 | 0.127 | -4.403 | 0.546 |
| Location | [Commuter_OccupancyInfo=0] | -1.592 | 0.638 | 6.223 | 1 | 0.013 | -2.842 | -0.341 |
| | [Commuter_OccupancyInfo=1] | 0[a] | | | 0 | | | |
| | [Commuter_Distance=0] | -1.535 | 0.708 | 4.703 | 1 | 0.030 | -2.923 | -0.148 |
| | [Commuter_Distance=1] | 0[a] | | | 0 | | | |
| | [Commuter_PlatformCrowding=0] | 0.404 | 0.635 | 0.404 | 1 | 0.525 | -0.841 | 1.649 |
| | [Commuter_PlatformCrowding=1] | 0[a] | | | 0 | | | |

Link function: Logit.
a. This parameter is set to zero because it is redundant.

### *A.2. Model 2*

**Parameter Estimates**

| | | Estimate | Std. Error | Wald | df | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower Bound | Upper Bound |
| Threshold | [Travel_Carriage6 = 1] | -5.131 | 1.234 | 17.288 | 1 | 0.000 | -7.550 | -2.713 |
| | [Travel_Carriage6 = 2] | -4.695 | 1.209 | 15.080 | 1 | 0.000 | -7.064 | -2.325 |
| | [Travel_Carriage6 = 3] | -4.192 | 1.188 | 12.447 | 1 | 0.000 | -6.521 | -1.863 |
| | [Travel_Carriage6 = 4] | -2.183 | 1.132 | 3.715 | 1 | 0.054 | -4.402 | 0.037 |
| Location | [Travel_OccupancyInfo=0] | -1.628 | 0.612 | 7.068 | 1 | 0.008 | -2.829 | -0.428 |
| | [Travel_OccupancyInfo=1] | 0[a] | | | 0 | | | |
| | [Travel_Distance=0] | -1.034 | 0.588 | 3.091 | 1 | 0.079 | -2.186 | 0.119 |
| | [Travel_Distance=1] | 0[a] | | | 0 | | | |
| | [Travel_PlatformCrowding=0] | -0.211 | 0.583 | 0.130 | 1 | 0.718 | -1.354 | 0.933 |
| | [Travel_PlatformCrowding=1] | 0[a] | | | 0 | | | |

Link function: Logit.
a. This parameter is set to zero because it is redundant.

### *A.3. Model 3*

**Parameter Estimates**

| | | Estimate | Std. Error | Wald | df | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower Bound | Upper Bound |
| Threshold | [Commute_Carriage9 = 1] | -4.301 | 1.708 | 6.339 | 1 | 0.012 | -7.648 | -0.953 |
| | [Commute_Carriage9 = 2] | -3.649 | 1.679 | 4.724 | 1 | 0.030 | -6.939 | -0.358 |
| | [Commute_Carriage9 = 3] | -2.591 | 1.653 | 2.456 | 1 | 0.117 | -5.831 | 0.649 |
| | [Commute_Carriage9 = 4] | -0.136 | 1.629 | 0.007 | 1 | 0.934 | -3.329 | 3.057 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Location | [Commuter_OccupancyInfo=0] | -1.937 | 0.686 | 7.965 | 1 | 0.005 | -3.282 | -0.592 |
| | [Commuter_OccupancyInfo=1] | 0[a] | | | 0 | | | |
| | [Commuter_Distance=0] | -0.262 | 0.730 | 0.129 | 1 | 0.720 | -1.692 | 1.168 |
| | [Commuter_Distance=1] | 0[a] | | | 0 | | | |
| | [Commuter_PlatformCrowding=0] | -0.361 | 0.696 | 0.269 | 1 | 0.604 | -1.724 | 1.003 |
| | [Commuter_PlatformCrowding=1] | 0[a] | | | 0 | | | |
| | [ExitKnowledge=0] | 0.857 | 0.598 | 2.056 | 1 | 0.152 | -0.314 | 2.028 |
| | [ExitKnowledge=1] | 0[a] | | | 0 | | | |

Link function: Logit.
a. This parameter is set to zero because it is redundant.

## *A.4. Model 4*

**Parameter Estimates**

| | | Estimate | Std. Error | Wald | df | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower Bound | Upper Bound |
| Threshold | [Travel_Carriage9 = 1] | -2.811 | 1.471 | 3.649 | 1 | 0.056 | -5.694 | 0.073 |
| | [Travel_Carriage9 = 2] | -1.730 | 1.455 | 1.413 | 1 | 0.235 | -4.582 | 1.122 |
| | [Travel_Carriage9 = 3] | -0.733 | 1.455 | 0.254 | 1 | 0.615 | -3.584 | 2.119 |
| | [Travel_Carriage9 = 4] | 1.582 | 1.455 | 1.183 | 1 | 0.277 | -1.269 | 4.433 |
| Location | [Travel_OccupancyInfo=0] | -2.057 | 0.639 | 10.365 | 1 | 0.001 | -3.309 | -0.805 |
| | [Travel_OccupancyInfo=1] | 0[a] | | | 0 | | | |
| | [Travel_Distance=0] | 0.330 | 0.596 | 0.306 | 1 | 0.580 | -0.838 | 1.497 |
| | [Travel_Distance=1] | 0[a] | | | 0 | | | |
| | [Travel_PlatformCrowding=0] | 0.710 | 0.616 | 1.326 | 1 | 0.250 | -0.498 | 1.918 |
| | [Travel_PlatformCrowding=1] | 0[a] | | | 0 | | | |
| | [ExitKnowledge=0] | 0.937 | 0.582 | 2.592 | 1 | 0.107 | -0.204 | 2.077 |
| | [ExitKnowledge=1] | 0[a] | | | 0 | | | |

Link function: Logit.
a. This parameter is set to zero because it is redundant.

## *A.5. Model 5*

**Parameter Estimates**

| | | Estimate | Std. Error | Wald | df | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower Bound | Upper Bound |
| Threshold | [Commute_Carriage12 = 1] | -3.802 | 1.609 | 5.581 | 1 | 0.018 | -6.955 | -0.648 |
| | [Commute_Carriage12 = 2] | -2.233 | 1.580 | 1.997 | 1 | 0.158 | -5.329 | 0.864 |
| | [Commute_Carriage12 = 3] | -1.448 | 1.569 | 0.851 | 1 | 0.356 | -4.524 | 1.628 |
| | [Commute_Carriage12 = 4] | 0.633 | 1.563 | 0.164 | 1 | 0.686 | -2.431 | 3.696 |
| Location | [Commuter_OccupancyInfo=0] | -2.201 | 0.665 | 10.954 | 1 | 0.001 | -3.504 | ` |
| | [Commuter_OccupancyInfo=1] | 0[a] | | | 0 | | | |
| | [Commuter_Distance=0] | 0.531 | 0.697 | 0.580 | 1 | 0.446 | -0.835 | 1.897 |
| | [Commuter_Distance=1] | 0[a] | | | 0 | | | |
| | [Commuter_PlatformCrowding=0] | -1.108 | 0.674 | 2.708 | 1 | 0.100 | -2.429 | 0.212 |
| | [Commuter_PlatformCrowding=1] | 0[a] | | | 0 | | | |
| | [ExitKnowledge=0] | 0.888 | 0.580 | 2.341 | 1 | 0.126 | -0.249 | 2.025 |
| | [ExitKnowledge=1] | 0[a] | | | 0 | | | |

Link function: Logit.
a. This parameter is set to zero because it is redundant.

*A.6. Model 6*

**Parameter Estimates**

| | | Estimate | Std. Error | Wald | df | Sig. | 95% Confidence Interval Lower Bound | 95% Confidence Interval Upper Bound |
|---|---|---|---|---|---|---|---|---|
| Threshold | [Travel_Carriage12 = 1] | -2.623 | 1.429 | 3.370 | 1 | 0.066 | -5.423 | 0.177 |
| | [Travel_Carriage12 = 2] | -1.439 | 1.422 | 1.024 | 1 | 0.312 | -4.227 | 1.349 |
| | [Travel_Carriage12 = 3] | -0.602 | 1.417 | 0.180 | 1 | 0.671 | -3.380 | 2.176 |
| | [Travel_Carriage12 = 4] | 1.277 | 1.412 | 0.817 | 1 | 0.366 | -1.492 | 4.045 |
| Location | [Travel_OccupancyInfo=0] | -2.424 | 0.627 | 14.943 | 1 | 0.000 | -3.654 | -1.195 |
| | [Travel_OccupancyInfo=1] | 0[a] | | | 0 | | | |
| | [Travel_Distance=0] | 0.284 | 0.580 | 0.239 | 1 | 0.625 | -0.853 | 1.420 |
| | [Travel_Distance=1] | 0[a] | | | 0 | | | |
| | [Travel_PlatformCrowding=0] | 0.028 | 0.597 | 0.002 | 1 | 0.963 | -1.142 | 1.198 |
| | [Travel_PlatformCrowding=1] | 0[a] | | | 0 | | | |
| | [ExitKnowledge=0] | 0.635 | 0.575 | 1.218 | 1 | 0.270 | -0.493 | 1.763 |
| | [ExitKnowledge=1] | 0[a] | | | 0 | | | |

Link function: Logit.

a. This parameter is set to zero because it is redundant.

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