How technology can impact customer-facing train crew experiences

Abstract

Customer-facing train crew have to follow strict procedures to guarantee that trains are safe and run on time. They are also responsible for revenue protection and customer care. Human factors and ergonomics research are instrumental to understand the safety-critical aspects and improve work. We bring user experience research and personas to describe how train crew perceive their routines and how new technology may impact them. We conducted seven hours of interviews and 30 hours of shadowing observations with train crew (n = 22) to provide an understanding of who are they and to define their experiences. We present crew's current routines and created two personas to represent them. One is slightly reluctant to adopt the proposed technology, whereas the other is more accepting. Results indicate how such technology may affect crew work ergonomics and experiences, and suggest which valuable aspects should be maintained, for example the positive interactions with passengers.

Keywords: Personas; user experience; crew; innovation; railways

Practitioner summary:

This study investigated the work routines of customer-facing train crew. Interviews and shadowing were conducted with 22 crew from a large operator in the UK. Personas were created to represent them. Results show their preferred activities and how these would be affected by the introduction of new technology.

Authors

Luis CR Oliveira (corresponding author)
WMG, University of Warwick
https://twitter.com/luibhz
https://orcid.org/0000-0003-3732-6410

Stewart Birrell
Institute for Future Transport and Cities, Coventry University
https://twitter.com/DrSBirrell
https://orcid.org/0000-0001-8778-4087

Rebecca Cain
Design School, Loughborough University
https://twitter.com/drrebeccacain
https://orcid.org/0000-0001-9453-0667

1. Introduction

Human factors and ergonomics research is often used in the railways to understand work routines and reduce human error (Shepherd and Marshall, 2005). Studies tend to focus on the activities performed by train drivers, for example, their interactions with the work environment and controls (Nathanael and Marmaras, 2018; Naweed et al., 2018). Qualitative data and observations are also used to understand tasks and behaviours when conducting trains (Naweed, 2014; Salmon et al., 2016) or evaluate the introduction of new technology for train drivers (Naweed and Rose, 2018). Although the work executed by train drivers is frequently studied, research with frontline staff is rare.

Customer-facing onboard crew engage directly with passengers, and this interaction can sometimes be emotionally demanding (Maria Stock et al., 2017; Oliveira et al., 2020). Crew are often subject to abuse from passengers (Salomonson and Fellesson, 2014), which can affect health and reduce job satisfaction (Boyd, 2002). Sometimes passengers can be inconsiderate towards crew or perform behaviours that are antisocial or even criminal (RSSB, 2010, 2009). Especially during disruption, "front-line staff are likely to bear the brunt of any shortfall" in service provision (Stafford et al., 2012, p. 807). Furthermore, the railways can be a stressful and traumatic environment for work due to a range of factors such as the risk of incidents (Queirós et al., 2014) and fatalities (Ryan et al., 2018). It is important to understand when and why these negative and positive events occur in order to evaluate the opportunities to improve crew experiences.

User experience (UX) is often applied to illustrate user perceptions when interacting with products and services. Experience can be defined as an episode or a length of time that one individual goes through (Hassenzahl, 2010), involving tangible perceptions through the senses and also feelings and thoughts. UX is a subjective judgement, dependent on users' moods, needs, expectations, time, place and social context (Forlizzi and Battarbee, 2004; Hassenzahl and Tractinsky, 2006).

UX in public transport is subject to growing interest from the public sector, academia and industry. Studies tend to focus on passengers and have been evaluating UX and satisfaction with travel through diverse methods, from large-scale surveys (Ettema et al., 2011), customer journey maps (Oliveira et al., 2017) to individual depictions of travel experiences (Jain and Lyons, 2008; Lyons et al., 2016). However, studies designed specifically to understand and improve customer-facing staff experiences are scarce. Working to improve the customer experience may indirectly improve the work quality for employees (Johnston and Kong, 2011), but staff experiences are seldom studied.

The need to understand crew experiences comes from the increasing demands faced by rail transport systems, and the propositions to introduce new technology into the railways. In the UK, there have been more crowding in some areas (DfT, 2018, 2017) and longer distances travelled in recent years (ORR, 2015a, 2015b). Technology can be introduced in several areas of rail transport, with the potential to improve the services overall, for example to spread the demand through less busy services

or help passengers finding a seat. Such innovations include pre-trip, on-board and post-trip information, fare collection and management and social media integration (Camacho et al., 2013; Foth and Schroeter, 2010; Islam et al., 2017; Keller and Schlegel, 2019; L. C. Oliveira et al., 2019).

User acceptance is an important aspect to consider before the implementation of new technological systems. In some cases, complex or disruptive systems are faced with severe resistance from employees (Venkatesh and Bala, 2008). Changes in habitual processes are subject to criticism and low intentions of adoption (Dawson et al., 2017). In the case of the rail industry, little is known about how train staff perceive their current journeys, and how the introduction of new technology would be received into this environment. The rare studies evaluating crew experiences when facing new technology consider the workforce as a single type of user (Oliveira et al., 2020). With the current study we suggest the need to define who they are, how they interact with current systems and the potential impact of the new technology. It is necessary to identify the characteristics of users to inform the design of systems which will better meet user requirements (Wilson and Norris, 2005).

Aims

This work was prompted by the possibility of designing new technology for the rail industry to improve aspects of seat reservation, ticket validation and interaction with passengers. As these features might directly affect crew experiences and work routines, we designed a study aimed at providing an understanding of this impact on different types of crew. To achieve this aim, it was necessary to provide an understanding of how crew experience their current journeys and describe how they interact with elements of the rail system. UX research and personas were used to provide real-life insights into crew characteristics, needs, attitudes and behaviours during their work on board trains. This research then suggests how crew relate to the introduction of innovative technology, and the potential positive and negative impacts of specific proposed features. Finally, this article presents the implications for design indicating the ways in how new rail technology should be designed to potentially improve work on board trains. Therefore, an appropriate research question is the following: What is the UX currently in place for crew working on board trains, and how would different types of crew face the introduction of new technology in this scenario?

2. Literature review

User-centred design (UCD) offers a suite of approaches for the understanding of users and their interactions with products and services (Haines and Mitchell, 2014). One of the design tools used to provide a clearer picture of users beyond market segmentations and demographics is *personas* (Cooper, 1999). Personas give a precise description of users and define what they wish to accomplish, representing archetypical users to facilitate the understanding of their behaviours, needs, motivations, characteristics and limitations (Goodwin, 2009; Haines and Mitchell, 2014; Marshall et al., 2015). Having a small set of personas makes the real users more tangible, especially for large organisations

or multi-partner projects with diverse stakeholders, where some of them are not familiar or not involved with the user research (Broberg et al., 2011; Mackrill et al., 2017). With personas, the users (or in the case of this paper, members of the workforce) are presented with realistic names, photos, some demographic information and textual descriptions to make them credible representations of the user population. Personas can be pragmatic tools for the development of products for specific users and their needs, and help during the prioritisation of product requirements (Miaskiewicz and Kozar, 2011). Burrows et al. (2015) presented smart home users via a set of personas to offer a richer picture of their experiences with technology in real-life contexts. In-depth interviews are usually the main data collection method to design personas, but practitioners may also use quantitative data to create their set of personas (Miaskiewicz and Luxmoore, 2017). Marshall et al. (2015) demonstrated how personas were used to evaluate the accessibility of rail transport and indicate failure points involving the ticket machines and navigation at stations. Another study with rail passengers created four personas to represent how users interact with the system, and how the introduction of technology would impact their journeys (Oliveira et al., 2018). By using personas, it is possible to motivate organisations to consider the user needs and inform user requirements during the development of new technology (Miaskiewicz and Luxmoore, 2017).

Scenarios

The creation of personas is usually set within a scenario, where the main users of a product or service are placed, both in space and time. “It is in scenarios that you can imagine how the product is going to work and be used, in what context it will be used and the specific construction of the product” (Nielsen, 2019, p. 8). With definitions of scenarios of use, the products and services emerge to be described and tested, thus adding value to the personas. Scenarios add a story to the work when they present events and actions in a sequence (Heijden, 2005). Similarly to a journey map, the concept of scenarios focuses on the stages of the encounter with a product or service and how experiences are affected by particular places and times (Reason et al., 2015). Knowing the work situations and where activities take place can facilitate the understanding of activities in context, for example as part of cognitive work analysis (Stanton et al., 2017b).

Technology at work

It seemed necessary to evaluate the current work routines and the needs, attitudes and behaviours of the workforce. Any new technology should not disturb the current organisational ergonomics, considering the intricate systems that constitute the railways (Schmid, 2001; Wilson, 2014), and the extensive safety procedures in place (RSSB, 2019). As stated by Wilson and Norris (2005, p. 651), it is necessary to “identify and communicate the characteristics of people which are relevant to design, implementation and operation of rail systems, equipment and jobs”. By doing so, it is possible to

support the (re)design of systems to better meet the needs of rail users, be it passengers or the workforce.

Rail crew roles

Understanding crew's perspective in relation to the introduction of new technology is particularly important given concerns about work quality and job security. There is evidence that some train crew demonstrate resistance to specific changes in the current work processes. For example, train operating companies are introducing driver-only operation (DOO), which removes the control of doors from train managers and gives this role to train drivers. Commuter trains and some new services being introduced in the network are already DOO, "with a second member of train crew only being provided where there is a commercial, technical or other imperative" (DfT, 2011, p. 208).

The removal of this safety-critical activity from the list of tasks performed by train managers proved to be highly contentious. This seems to be the main reason for strikes in diverse areas in the UK (BBC News, 2015; GetReading, 2015; The Independent, 2017; The Scotsman, 2016). Even though these changes may present financial advantages and make use of new technology, there is the concern that the railways could become a "more de-staffed and de-humanised environment" (Prentice, 2015, p. 1) and create more problems than it tries to solve.

The tendency seems to consider that train managers will be retained only on routes over long distances, where they can perform the revenue protection and collection – checking and selling tickets on board (DfT, 2011). Smaller, remote stations also indicate the need to keep a second member of crew on board, since generally there are no ticket barriers nor platform staff available at these locations. This creates the possibility for people travelling for free and passengers not receiving the care needed, especially considering the growing demand for assisted travel (Prentice, 2015). The Transport Committee (2016) suggests that, once train managers do not have to control the doors, they may have more time to dedicate to other tasks such as checking and selling tickets, and to be available for more personal interactions with passengers, giving information and assistance. The need for modernisation brought about new technology combined with the risk of side effects such as user resistance and conflicts indicate that more research is needed to understand how crew work may be affected by technologies introduced by the rail industry.

3. Methodology

This research used interviews and direct user observation to understand customer-facing crew experiences on board trains, to illustrate their work and present their needs, attitudes and behaviours in specific situations. It follows the main principles of user-centred design, which states that the design of products, services and systems has to be "based upon an explicit understanding of users,

tasks and environments", users must be "involved throughout design and development" and the design should address "the whole user experience" (ISO, 2019, p. 6).

Participants were recruited from one large train operating company in the UK, facilitated by their station managers, according to crew availability on the locations and days selected for this research. There were no incentives for participation. The sample for this research comprised of 22 crew members: 17 train managers (TMs), who are the main authority on board, and five customer hosts (CHs), who sell refreshments and provide customer care. Eight crew members (5 CHs and 3 TMs) took part in the interviews, and the shadowing activity was performed with 15 TMs. One of the TMs was interviewed and shadowed, hence the total number of participants in this study is 22 and not 23.

3.1. The proposed technology

This research considered a scenario where technological developments allowed the introduction of innovations via smartphone applications and station screens to benefit passengers' journeys. These innovations would also need to be used by customer-facing crew via portable devices and onboard interfaces. Participants were asked to comment on a list of features in order to evaluate their perceptions and acceptance of the technology. The following items have been proposed as part of a package of innovations that can be introduced for passengers (L. Oliveira et al., 2019). Since these features have the potential to affect the way crew perform their work activities, it was therefore fundamental to understand the possible impact from their own perspectives.

- Passengers will have the ability to validate tickets electronically at their seats, so crew will not need to inspect tickets from these passengers
- Crew will have a phone or tablet application to see in real-time a diagram of the train with occupancy levels and colour-coded seats showing empty, reserved, occupied seats and which passengers have a valid ticket
- Passengers will be able to access live information showing the occupancy levels of current and future trains. They will also have the ability to search for, reserve and/or change seats before and during journeys
- Passengers will have directions displayed on their phones to help them find the platform, the location of the coach upon arrival of the train and the exact position of their seat
- Passengers will have access to live journey information (e.g. ETA and alternative travel routes, especially in the event of disruptions)
- Passengers will have information on facilities at the destination station (e.g. details of bus connections and phone number of taxis)
- Passengers will have the ability to earn rewards through a loyalty scheme and redeem points for rail or non-rail purchases
- Passengers will have the ability to pre-order special services (e.g. refreshments or train manager assistance)
- Passengers will have automatic compensation for late or cancelled trains

3.2. Interviews

Face-to-face semi-structured interviews were performed to understand user expressions of attitudes, feelings, preferences, needs and behaviours (Table 1). The initial part of the interview used for this study captured crew's perceptions in relation to the current train systems. Questions explored their work routines, who they work with, what hardware and which technology they use. We asked about issues around seat reservations, ticket validation, challenges in performing their jobs, and the parts of the work they enjoy most and least. The interviewer then disclosed the list of proposed technological innovations via a PowerPoint presentation on a laptop screen containing diagrams of the system. When participants had understood the proposed technology, we performed the second part of the interview. Questions were placed in order to obtain participants' impressions related to the technology. Questions explored likes, dislikes, and if/how the features would affect their work activities.

The interviews produced a total of 7 hours and 15 minutes of recordings, an average of 57 minutes per interviewee. The interviews were all recorded and transcribed to allow a thematic analysis (Braun and Clarke, 2006), which was performed using QSR International NVivo software.

Table 1 – Semi-structured interview questions (from Oliveira et al., 2020)

Area	Main question	Sub-questions and prompts
Setting the scene	What are your daily activities?	Please describe scenarios for these activities
Human interaction	Who do you work with daily to perform your job?	How do you work with them? Do you have to follow any specific rules/training?
Human-computer interaction	Which tools/technology do you use to perform your job (if any)?	How / why do you use them? What works? What doesn't?
Challenges	What are the challenges in performing your daily job?	
Seat reservation	What challenges do you have to deal with around seat reservations?	Are these affected by the type of the service (no. of coaches, size, design of seats, onboard tech?) Nature of the service (direct, slow train?) Time of the day (peak / off-peak?) Seasonal fluctuations (holidays, seasons?) What aspects of the current systems work well? Why? What could be improved? What do you perceive to be the customers' issues with this system? Do you observe different issues for different types of customers?
Ticket validation	What challenges do you have to deal with around checking tickets?	Are these affected by the type of the service (no. of coaches, size, design of seats, onboard tech?) Nature of the service (direct, slow train?) Time of the day (peak / off-peak?) Seasonal fluctuations (holidays, seasons?) What aspects of the current systems work well? Why? What could be improved? What do you perceive to be the customers' issues with this system? Do you observe different issues for different types of customers?

Work experience	What is the part of the work that you enjoy most / least?	Why?
(Show presentation about proposed technology)		
Work fit	How do you think this project might help your daily work?	
Positives and negatives	What do you like about the project? What problems do you see?	How do you see a system like this working in future?
Closing remarks	Is there anything else we should know?	

3.3. Shadowing

The second data collection methodology adopted for this research was the observational method of 'shadowing', when a trained researcher investigates, unobtrusively, the activities that individuals perform as they go about their business. Shadowing involves a field visit, which gives the opportunity to observe and meet people where they are comfortable, at their habitual places of work. It can lead to specifications of concrete details about work activities, and this knowledge can help write requirements to be implemented in subsequent development phases (Kuniavsky et al., 2012).

During the shadowing performed as part of this research, participants were aware of the presence of the researcher, but were asked to perform the duties as naturally as possible. All train managers were familiar with shadowing and had done it themselves because it is part of the training process to learn their job.

Train services were selected randomly at terminus stations, where the corresponding crew were recruited. After introducing himself and explaining details of the process, one of the researchers obtained signed consent and started collecting data. The researcher boarded regular intercity trains in the South and West England and Wales and followed the TM on their assigned journey.

The researcher registered all major tasks performed by TMs during a train journey to obtain as much information about as many activities as possible in this scenario to provide a simplified hierarchical task analysis, customary in ergonomics research (Rose and Bearman, 2012; Stanton, 2006). A log sheet contained the time of occurrence (registered as hour:minute at the beginning of the activity), what the TM was doing, and where it took place. Whenever possible, additional information was registered such as how and why the activities were performed. The researcher also took pictures of specific aspects of the work and journey.

At the end of the shadowing process, participants were asked a few questions to clarify some issues observed. This debriefing session was designed so crew could describe these issues, illustrate their frequency, and explain their impact on work and on how they feel. By revisiting the activities performed, participants were able to add meaning to them and enrich the hierarchical task analysis (Lenz et al., 2019). The researcher also presented the technological innovations above via printed sheets to obtain crew's impressions and opinions.

The shadowing study was performed in six days of fieldwork, in April and May 2016. A total of 30 hours and eight minutes on board trains resulted in an average observation of two hours per TM. Approximately four hours were used for the debriefing sessions, resulting in almost 26 hours of shadowing. Log sheets containing 562 observations were transcribed to MS Excel where the numeric data was subject to quantitative analysis using pivot tables.

3.4. Persona development

The methodology used for creating the personas presented below derives from Cooper's seminal work (1999) and its developments (Goodwin, 2009), as used extensively in persona creation (for example Burrows et al., 2015; Haines and Mitchell, 2014). The information obtained from the interviews and shadowing exercises was tagged into specific codes, which are the units of qualitative information, giving 255 tags. These codes were clustered into themes to indicate their frequency and importance. The main themes obtained from the interviews, together with the sequential incidents of the interaction obtained from the shadowing exercise (Jüttner et al., 2013) were organised by the researchers to understand what crew had in common, what were the problems that appeared more frequently, and if there were shared aspirations (Kuniavsky et al., 2012). The next step was to convert these themes into user characteristics, and these became ranges or variables that fed into the persona development process. Participants were then classified according to their position on this range. These attributes are not binary, rather they reflect a continuum from a negative to a positive user perception (Burrows et al., 2015). With all data plotted, individuals started to be seen together on different variables, indicating initial trends (Haines and Mitchell, 2014). After some iterations, patterns of characteristics and clusters of users started to arise, indicating where some participants could be grouped as one of the user personas (Goodwin, 2009).

4. Results

The shadowing technique allowed the categorisation of individual tasks performed by TMs. Table 2 shows the duration of each activity and the equivalent percentage of time spent on tasks. TMs spend 19% of their journey time checking tickets, followed by 17% dedicated to the activity of opening and closing doors at each calling point. The door procedure was always coupled with announcements before and after each stop, accounting for 15%. Customer care took approximately 14% of the journey time, and these activities comprised giving information, helping passengers with diverse types of needs or allowing passengers to store or retrieve their bikes. TMs may sell tickets on board trains, using 6% of their time on average. At the end of the journey they count money and card transactions, and fill in forms reporting sales (4% of time). Some TMs performed a manual passenger count (2%). Five participants had to deal with safety issues such as unattended bags on board and passengers' dangerous behaviours on platforms. Maintenance issues involved diverse tasks, from trying to switch off the heating system in a boiling coach, to fetching paper towels to a toilet. On busy services with paper seat reservations, three TMs were seen removing these tags from unclaimed seats. The final

18% of the time was used for non-work related activities, such as having a coffee break, going to the toilet, or chatting with colleagues.

Table 2 - Time spent on major tasks (also in Oliveira et al., 2020)

Activity	**Duration (hours:minutes)**	**%**
Checking tickets	05:01	19.31
Door procedure	04:31	17.38
Announcements	03:48	14.62
Customer care	03:38	13.98
Selling tickets	01:39	6.35
Cashing up	01:00	3.85
passenger count	00:31	1.99
Safety issues	00:21	1.35
Maintenance	00:19	1.22
Reservations	00:18	1.15
Other (waiting, walking, breaks, toilet, chatting with colleagues)	04:53	18.79
Total	25:59	100.00

The thematic analysis indicated that crew could be classified into variables within three main themes shown in sections 4.1 to 4.3. First, we describe their relationship with the rail system in terms of technology acceptance and familiarity, exploring opinions regarding the fit of technology within their scenarios of work and the need for change. We also noticed that participants differed in the way they approach the tasks of revenue protection and their contact with passengers. Finally, we observed different perceptions of job security in face of the possible introduction of new technology. Quotes from participants are presented to illustrate these variables. The resulting two main personas are presented below in section 4.4. The final results section presents a summary of the impact of proposed technology on crew work situations.

4.1. Technology acceptance, familiarity and fit

Some of the train crew were happy to adopt new technology and adapt to accommodate changes in the current activities, especially if it helps to reduce the mechanical and repetitive tasks. Participant 3 [P3] exemplifies: "*We have to be forward. Anything we can do to make it better, you've got to do it, there's no choice… I'm totally for it*". Participants mentioned situations they believe new technology can improve their job experience, for example when asked about electronic ticketing and passengers' self-validation of tickets: "*Some train services have stops every 5 minutes, so it would be good to save time on tasks such as checking tickets*" [P16]. P18 complements: "*We have pockets of time and usually thousands of people on trains, so anything that can speed up our work is welcome*".

Figure 2 – Train manager reading the next calling points from paper

However, some crew members reported concerns in relation to changes that the new technology could bring. These concerns were mainly about passengers needing to use new procedures, which could bring confusion, and also themselves having to change how to perform tasks. Participants demonstrated some resistance to the new technology as ticket validation and customer care are usually coupled, and removing the former may affect the latter. Crew do not want to lose the opportunity to do customer care, because they acknowledge some passengers need it, and because it is a part of the job that they enjoy. P20 gives their opinion: "*The contact with customers is still important. That's when we give them reassurance, we describe, improve, give advice as we do it. That's what I do by checking their tickets*". Smartphones were used to give better announcements or personal advice to passengers (Figure 2), but some TMs preferred to use the old piece of paper to consult the next stops and arrival times (Figure 1).

Figure 1 – Train manager getting extra information from her smartphone

4.2. Dedication to revenue protection

TMs had different motivations and provided a number of different explanations for checking (or not) tickets. It depends on the origin, destination and the part of the journey they are, and some TMs were more lenient towards passengers without a valid ticket for that train. TMs can earn a small percentage

of their monthly ticket sales (after a certain threshold), representing an incentive for revenue protection if the ticket price is high. Participant 22 described their reasons for not checking tickets on certain parts of the journey: "*On trains from Bristol to Severn Beach, there are stations every 2 minutes, and it makes no sense to check tickets because they're like £2.50*". Other train managers are keen to check every passenger, sometimes even waking them up or issuing an unpaid fare notice to a passenger without the right railcard.

Interviewees mentioned that most of the time at work on board trains is checking tickets, and this information was validated by the shadowing study. However, revenue protection is at the bottom of their hierarchy of priorities. The first and most important goal is to guarantee the safety of passengers and the system as a whole. Secondly, to keep the trains running on time. Thirdly, TMs have to provide customer service, giving information and assistance to passengers. The least important item mentioned by crew was to perform the revenue protection, checking and selling tickets. If there are safety issues, delays or there is the need for extra customer care, the revenue protection is compromised, meaning that tickets may not be checked at all. P3 exemplifies this order of importance: "*If things are going wrong, I flip to the customer service end. If everything is running fine, I concentrate on the tickets*".

4.3. Perception of job security

When presented with the application that allows passengers to check-in at their seats and validate their tickets, some voiced concerns that their jobs will be at stake. P6 exemplifies with her concerns: [If passengers validate their own tickets, companies may] "*get rid of the train manager because they're not needed anymore* [laughs]. *People need reassurance, and this is very clinical, and impersonal*". Similarly, P20 was vocal on the resistance to a technology proposing changes in current roles and responsibilities: "*I will rather not use the system, I'm here to tell passengers about connections, time, platforms, railcard validity and so on. It seems that it's undermining my role. I won't support anything that disregards what I do and I think I do very well*".

Other crew were positive about certain changes such as reducing the effort dedicated to revenue protection. Those acknowledged that change is necessary, and that they are still needed for other more challenging activities. TMs often mentioned their priorities and that technology could change their work tasks, but not necessarily negatively. P3 exemplifies that he could reduce the amount of repetitive, mechanical tasks to concentrate on customer care or dealing with major incidents:

> *I think it's fair to say, my main role is safety. The technology is there to replace my part in it, it is. Which means I need to evolve and do something else. If me evolving means I'll give that man a cup of tea, make his day better, I'd say thank very much, I'll do that. I've got to evolve. We will still hit all the cows.* […] *All the technology in the world isn't going to stop a sheep wandering onto the track* […] *or a drunken bum throwing a bottle at the windscreen of a train. So the list is endless, how my day can change like that.*

4.4. Personas

The analysis of data from interview and shadowing with train crew indicated that there are two main personas to represent customer-facing staff working on trains, on their relation to the introduction to new technology. The first type is Samantha, an experienced professional slightly sceptical about innovation. The second is Charles, quite the opposite, a young professional eager to see modernisation to improve the technology currently in place. The sections below present details of these two personas via the 'persona card' and a description of their characteristics.

4.4.1. Samantha

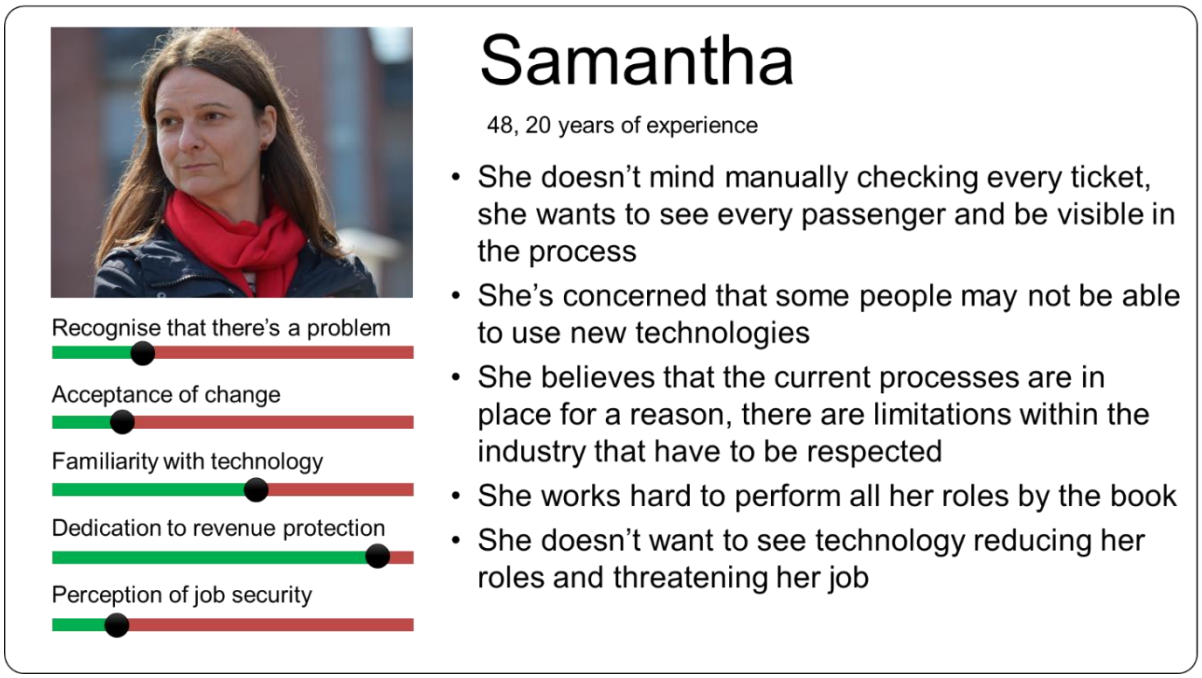

Figure 3 – Persona card 1: Samantha

Samantha starts her shift preparing all the equipment in advance to start checking tickets early. She begins the revenue protection from first class, to ensure that those passengers are entitled to receive the complimentary items. When checking tickets, she provides information about changes and even platforms and train times at other stations, from her own knowledge acquired after decades of experience. When facing ticketless travel, she is keen to issue unpaid fare notices so that person does not get away with that (and to assure and be fair with all the other passengers who paid a lot for their tickets). She had seen things going wrong in the railways, so she is more focused on issues at stations when opening and closing doors. She does not want people to get hurt, and is worried that passenger behaviours can delay trains and stain her safety and performance record.

Samantha thinks the introduction of new technology on board trains should be made with care. If it helps passengers to stand on the platform at the right place, board quickly, locate their seats easily and minimise conflicts, it would be really appreciated. However, she does not want to see passengers becoming worse off, particularly inexperienced travellers. She does not want to lose the personal

contact with passengers, therefore she is resistant to see them validating tickets themselves and not needing her services anymore. That is seen as a threat to her job, and she may voice it in a similar way to when her management said she would not control the train doors anymore. She is also concerned about the older adults and other vulnerable passengers being potentially excluded from the benefits brought up by the innovation.

4.4.2. Charles

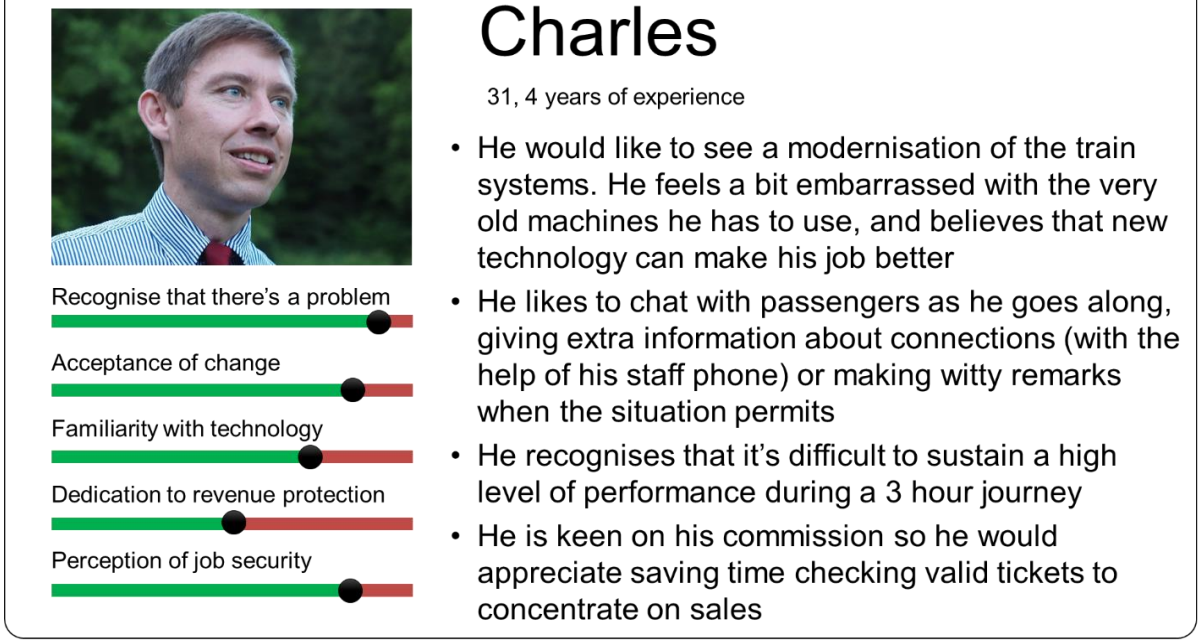

Figure 4 – Persona card 2: Charles

When Charles starts his shift, he stays at the platform for a few minutes to meet and greet passengers and give special care for leisure travellers or anyone who looks lost. After dispatching the train, he soon checks tickets in first class, where he can get larger sale commissions. He then usually has his coffee, chat with other crew and get prepared for the next calling stations. When going through major stations or around London he is not very inclined to check tickets since most people already have them, and stations have barriers anyway. After the main stations are gone, he proceeds to check tickets in standard class coaches. He does not put a big fight if someone does not have a ticket, that may be a genuine mistake, and there is no point in making everybody stressed or delaying the train. He carries on doing what he likes, which is giving information and chatting with passengers.

Charles is accepting of new technology, relaxed in relation to changes in some processes, and understands that his role is still necessary regardless of the innovations brought on board trains. He believes that he is still needed for safety, keeping the trains on time and customer care. The time-consuming tasks such as checking tickets can be improved or removed altogether. When presented with new technology he would be happy to embrace it. He feels he is more useful when there is

customer care to perform, when there is disruption, and when the trains are full. In these situations, he can be a train manager rather than just a ticket examiner.

4.5. The impact of the proposed technology

Table 3 presents an analysis of crew work activities based on the contextual activity template (Stanton et al., 2017b). It confronts the work situations with the processes related to the proposed technology. The work situations are shown on the top row, and reflect the most frequent activities presented in Table 2 above. The first column lists the object-related processes and activities, which in this case are the features proposed as technological innovations.

The text in the table summarises where the work situations may be affected by the technology. The first cell of the table indicates a negative influence, where the electronic validation of tickets might worsen the customer care performed by both personas. If passengers validate their tickets, there is no need for crew to approach them, compromising activities that crew enjoy such as chatting with passengers and giving information. All the subsequent matches between work situations and technology show mainly positive influences, for example the reduction of the time consuming manual ticket checking. With a diagram of seat occupancy in real-time, crew will be able to pinpoint where to check tickets and potentially sell them. It will also make possible the automatic count of passengers.

If passengers can see the occupancy levels of later trains they will be better informed and may opt for a less crowded service, improving the efficiency and safety, therefore reducing problems at the platform-train interface (PTI). With the ability to change seats, the application may be able to clear unclaimed reservations, freeing seats if passengers do not board that service. With directions displayed on passengers' phones to help them find the platform, the location of their train carriage and the exact position of their seat, passengers will be more likely to occupy their reserved seats. This feature can also improve the efficiency and safety at the PTI.

The ability to pre-order special services may cause an increase in workload but perhaps compensate for less time checking tickets. Therefore crew may consider it as a positive addition. It can make it easier to identify passengers in need of assistance, and constitute activities that crew enjoy. The remaining features of live journey information, list of station facilities, a loyalty scheme and automatic compensation for delays and cancellations have the potential to improve the customer service as a whole and to provide a better passengers' experience, indirectly resulting in an enhanced experience for train crew.

Table 3 – The impact of technology on activities of train crew. (*) indicates a negative influence

	Customer care	Check tickets	Sell tickets	Reservations	Door procedure	Safety issues	Passenger count
Electronic validation of tickets	No interaction with	No need to check					

	passengers (*)	valid tickets					
Real-time diagram of seat occupancy and validated tickets		Pinpoint where to check tickets	Pinpoint where to sell tickets				Real-time count of passengers
Occupancy levels future trains and ability to change seats before and during journeys	Passenger better informed			Unclaimed reservations are cleared	Safer PTI	Safer PTI	
Information about platform and the exact position of their seat	Passenger better informed			Passenger more likely to occupy their reserved seats	Safer PTI	Safer PTI	
Ability to pre-order special services and assistance	Increase workload, but may secure job, and do what they enjoy doing						
Live journey information (e.g. ETA and alternative travel routes)	Passenger better informed						
Information on facilities at the destination station	Passenger better informed						
Loyalty scheme for passengers	Benefit for passenger						
Automatic compensation for late or cancelled trains	Passengers' reassurance and peace of mind, fewer conflicts						

5. Discussion

This paper had as the main aim to provide real-life insights into crew characteristics, and indicate how these characteristics may be affected by the introduction of innovative technology into the railway systems. The results presented here shed a light on crew experiences on board trains from the perspective of two personas: one clearly more resistant to the introduction of new technology on trains (Samantha), and the other more accepting (Charles). Practitioners recommend that technology should be designed for a primary persona, who is the main user of a product or service (Goodwin, 2009). The

difficulty here is that both personas should be catered: if the proposed technology is to be introduced across operators, employees may not have a choice. Developers should allow enough adaptation and customisation so the applications are able to "bend and stretch and adapt to the user's needs" (Cooper, 1999, p. 127).

Human factors and ergonomics research can provide the methodology to ensure that the new technology is designed in such way that allows customer-facing train crew to perform their roles safely and efficiently, similarly to the studies performed with train drivers (Naweed, 2014; Salmon et al., 2016). A simplified hierarchical task analysis (Stanton, 2006) was instrumental to map the activities performed by crew, indicating the amount of time spent on tasks and the major issues encountered within their work scenarios. Additionally, a contextual activity template (Stanton et al., 2017b) facilitated the analysis of the effect that the technological features could have on crew work. UX research methods explored issues such as technology acceptance, user preferences, perceptions of job security and individual experiences within different situations at work. Personas were used to give this highlight these individualities and to provide an understanding of the impact of new technology on different types of train crew.

For both personas, the two main priorities, namely to guarantee the safety of the system, and to keep trains on time, should not be compromised by changes introduced by technology. The expectation is that certain features will improve safety and reduce dwell time: the information about where to stand to reach your seat may reduce the concentrated boarding (L. C. Oliveira et al., 2019) and there may be fewer passengers running down the platform to find their carriage (Oliveira et al., 2017). However, crew was concerned that changes in the revenue protection methods may undermine their roles, reduce tasks and affect their ability to perform customer care. Given the importance of technology acceptance and the risk of crew resistance, designers should take in consideration ways to enhance experiences whilst avoiding the elimination of valued or enjoyable tasks.

5.1. Implications for design

From the list of technological innovations analysed via the contextual activity template (Table 3), the feature to raise more concerns among both personas is the electronic ticket validation. If crew see on the application which passengers have validated their right to travel, they will not need to inspect their tickets. This feature can reduce mechanical and time-consuming work, and directly improve work ergonomics. However, the crew UX is then threatened, as the personal contact with passengers is valued by both personas. Samantha sees it as a reduction of her ability to interact with passengers who may be in need of care and assistance. It also raises concerns about reducing her roles and risking her job. The elimination of onboard activities such as the control of doors was met with strong resistance by crew (Prentice, 2015). With conversation starters removed, Charles will have fewer opportunities to have amusing conversations with passengers. The introduction of automatic ticket validation should

not ‘design out’ probably the most enjoyable part of the journey for both personas. This feature has the potential to worsen crew experiences, therefore one of the suggested requirements is to provide ways to engage crew and passengers in positive interactions, avoiding the common conflicts between these two groups (Maria Stock et al., 2017).

If the application reduces the need for manual ticket checking, one possible design solution is to allocate equivalent time on activities they enjoy and deem important, such as giving bespoke customer care. Crew assistance can be requested via the same platform, so the crew-passenger interaction can happen on demand. That will allow a way of selectively performing customer service. Crew could become more customer-focused, distancing themselves from the adversarial role of a revenue collector.

Previous research indicates that passengers do not want to pre-order services, refreshments and crew assistance, perhaps because most passengers see that these options are irrelevant or could increase fares (L. Oliveira et al., 2019). The recommendation here is to distant this feature from ‘order special services’ and rephrase it as ‘get assistance or more information’, to give passengers the reassurance that their journey (including routes, connections and price paid) is the best possible. Samantha will still feel useful for sharing knowledge with those who need it, and Charles will have opportunities to engage in conversations with some passengers.

5.2. Limitations and future work

The use of personas as a method may present some challenges and limitations, especially in relation to relevance and validity (Chapman and Milham, 2006) and be sometimes stereotypical (Turner and Turner, 2011). However, if based on solid data and not in assumptions, it is possible to generate useful personas to inform the design of product and services (Marshall et al., 2015). There is agreement among practitioners that personas can help focus on the audience, to develop products for the users and their goals, and can help during the prioritisation of the product requirements, to determine if the right problems are being solved (Miaskiewicz and Kozar, 2011).

This study used a simplified hierarchical task analysis (Rose and Bearman, 2012) to describe the activities performed by train crew. We understand that more complete methods from human-factors and ergonomics could be used to capture these activities and produce more complex diagrams including decision-making processes (Stanton, 2006). However, the dynamic environments on board trains prevented a full ergonomics evaluation of procedures and tasks. Our study was designed to observe crew in their real contexts, and we added debriefing sessions after the observations to explore underlying issues, obtain justification for behaviours, and improve reliability.

The current study applied a contextual activity template to understand the impact of technology in work situations. Future work could incorporate a broader analysis of the work domain of train crew

using more steps of the cognitive work analysis toolkit (Salmon et al., 2016; Stanton et al., 2017b). It is possible to perform a multi-level study of the activities, from the physical objects and processes that crew have to interact with, to the activities needed to achieve priorities and functional purposes of work on board trains (Birrell et al., 2012; Stanton et al., 2017a). Although interesting and useful for understanding work routines, these analyses were beyond the scope of our study.

It is understood that qualitative data analysis can be subjective and down to the interpretation of the researchers and the subtleties of the English language (Long and Johnson, 2000). Here, we took speech and actions and converted them into variables on scales in order to define users. It has been a challenge to understand the underlying emotional estates related to safety-critical work such as the railways (McLeod et al., 2005). To minimise subjectivity and biases, part of the data was examined by a second researcher to provide cross-researcher reliability. An additional strategy was triangulation, targeting the phenomena from two points of view. Through the combination of interviews and shadowing, which had the objective measures of a task analysis, we improved the chances of our results being a reasonable representation of the attitudes, needs and behaviours of the sample.

The data collected during this study came from a small number of crew members working for one train operating company, on journeys for one specific area of the UK, during a limited timeframe. The personas generated were presented to the project consortium and funding body for internal validation. Future work could be performed to validate these personas (and possibly refine or expand them) using larger datasets and different types of data. Practitioners have been using a combination of qualitative and quantitative data to create more robust personas and to update them periodically (Miaskiewicz and Luxmoore, 2017). The addition of quantitative methods can also be useful to measure the share of the user base represented by each persona (Miaskiewicz and Luxmoore, 2018).

Nevertheless, the results presented here can be used to guide the development of technological innovation to the rail industry by eliciting existing user behaviours, needs, motivations, characteristics and limitations of crew. Given the potential for crew resistance, further exploratory studies can start from our personas and develop ways to increase acceptance of new rail technology. It can also be used to inspire workshops, focus groups and other exploratory activities with crew. Companies can invite a group of employees to evaluate the features of the technology in detail to map the real resistance to innovation and define the modifications required. Surveys can also indicate the potential strategies for smooth implementation that could facilitate the adoption of technology (Venkatesh and Bala, 2008).

6. Conclusion

With this research, we hoped to advance the knowledge of user research in rail transport and train crew UX by presenting two staff personas based on empirical evidence. By talking about specific

crew personas instead of a generic user, it is possible to define more clearly how technology would impact existing experiences, and how innovation could be designed to improve individual experiences during their work on board trains. We believe that these results can help inform the design of innovative technology with the potential to improve rail systems as well as meet crew needs.

Our two personas have one major similarity, that they appreciate the interaction with passengers on board trains. Technology can modernise the way passengers prove their right to travel, therefore eliminating the need for this interaction. However, the same application can allow passengers to request crew assistance and customer service whenever needed, selectively fostering valuable interactions. Keeping these personas in mind throughout the design process, and using UX design alongside ergonomics methods, it is possible to improve the chances of acceptance and adoption of innovative rail technology.

Acknowledgements

This research is performed as part of the "CLoSeR: Customer Loyalty and Dynamic Seat Reservation System" project, funded by RSSB / Innovate UK (Grant No 102483). This project was selected through the competition 'Enhancing Customer Experience in Rail'.

Conflict of interest

No potential conflict of interest was reported by the authors.

References

BBC News, 2015. First Great Western services disrupted in rail 24-hour strike [WWW Document]. URL http://www.bbc.co.uk/news/uk-england-34026450 (accessed 2.1.16).

Birrell, S.A., Young, M.S., Jenkins, D.P., Stanton, N.A., 2012. Cognitive Work Analysis for safe and efficient driving. Theor. Issues Ergon. Sci. 13, 430–449. doi:10.1080/1463922X.2010.539285

Boyd, C., 2002. Customer Violence and Employee Health and Safety. Work. Employ. Soc. 16, 151–169. doi:10.1177/09500170222119290

Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qual. Res. Psychol. 3, 77–101. doi:10.1191/1478088706qp063oa

Broberg, O., Andersen, V., Seim, R., 2011. Participatory ergonomics in design processes: The role of boundary objects. Appl. Ergon. 42, 464–472. doi:10.1016/j.apergo.2010.09.006

Burrows, A., Gooberman-Hill, R., Coyle, D., 2015. Empirically derived user attributes for the design of home healthcare technologies. Pers. Ubiquitous Comput. 19, 1233–1245. doi:10.1007/s00779-015-0889-1

Camacho, T.D., Foth, M., Rakotonirainy, A., 2013. Pervasive Technology and Public Transport: Opportunities Beyond Telematics. IEEE Pervasive Comput. 12, 18–25. doi:10.1109/MPRV.2012.61

Chapman, C.N., Milham, R.P., 2006. The Personas' New Clothes: Methodological and Practical Arguments against a Popular Method. Proc. Hum. Factors Ergon. Soc. Annu. Meet. 50, 634–636. doi:10.1177/154193120605000503

Cooper, A., 1999. The inmates are running the asylum, 1st ed. Sams, Indianapolis, IN.

Dawson, C.H., Mackrill, J., Cain, R., 2017. Assessing user acceptance towards automated and conventional sink use for hand decontamination using the technology acceptance model. Ergonomics 1–13. doi:10.1080/00140139.2017.1316018

DfT, 2018. Transport Statistics Great Britain [WWW Document]. Dep. Transp. URL

https://www.gov.uk/government/statistics/transport-statistics-great-britain-2018 (accessed 2.27.19).
DfT, 2017. Rail passenger numbers and crowding on weekdays in major cities in England and Wales [WWW Document]. Dep. Transp. URL https://www.gov.uk/government/statistics/rail-passenger-numbers-and-crowding-on-weekdays-in-major-cities-in-england-and-wales-2015 (accessed 5.31.17).
DfT, 2011. Realising the Potential of GB Rail [WWW Document]. Dep. Transp. URL https://www.gov.uk/government/publications/realising-the-potential-of-gb-rail (accessed 9.23.19).
Ettema, D., Gärling, T., Eriksson, L., Friman, M., Olsson, L.E., Fujii, S., 2011. Satisfaction with travel and subjective well-being: Development and test of a measurement tool. Transp. Res. Part F Traffic Psychol. Behav. 14, 167–175. doi:10.1016/j.trf.2010.11.002
Forlizzi, J., Battarbee, K., 2004. Understanding experience in interactive systems, in: Proceedings of the 2004 Conference on Designing Interactive Systems Processes, Practices, Methods, and Techniques - DIS '04. ACM Press, New York, New York, USA, p. 261. doi:10.1145/1013115.1013152
Foth, M., Schroeter, R., 2010. Enhancing the experience of public transport users with urban screens and mobile applications. Proc. 14th Int. Acad. MindTrek Conf. Envisioning Futur. Media Environ. - MindTrek '10 33. doi:10.1145/1930488.1930496
GetReading, 2015. First Great Western: rail union plans strike ballot over staffing of new trains [WWW Document]. Get Read. News. URL http://www.getreading.co.uk/news/reading-berkshire-news/first-great-western-rail-union-9004372 (accessed 2.1.16).
Goodwin, K., 2009. Designing for the Digital Age: How to Create Human-Centered Products and Services. John Wiley & Sons.
Haines, V., Mitchell, V., 2014. A persona-based approach to domestic energy retrofit. Build. Res. Inf. 42, 462–476. doi:10.1080/09613218.2014.893161
Hassenzahl, M., 2010. Experience Design: Technology for All the Right Reasons. Synth. Lect. Human-Centered Informatics 3, 1–95. doi:10.2200/S00261ED1V01Y201003HCI008
Hassenzahl, M., Tractinsky, N., 2006. User experience - A research agenda. Behav. Inf. Technol. 25, 91–97. doi:10.1080/01449290500330331
Heijden, K. Van Der, 2005. Scenarios: The Art of Strategic Conversation, 2nd ed. John Wiley & Sons Inc.
Islam, M.F., Fonzone, A., MacIver, A., Dickinson, K., 2017. Modelling factors affecting the use of ubiquitous real-time bus passenger information. 5th IEEE Int. Conf. Model. Technol. Intell. Transp. Syst. MT-ITS 2017 - Proc. 827–832. doi:10.1109/MTITS.2017.8005627
ISO, 2019. Ergonomics of human-system interaction - Part 210: Human-centred design for interactive systems (ISO 9241-210) [WWW Document]. Int. Organ. Stand. URL https://www.iso.org/standard/52075.html
Jain, J., Lyons, G., 2008. The gift of travel time. J. Transp. Geogr. 16, 81–89. doi:10.1016/j.jtrangeo.2007.05.001
Johnston, R., Kong, X., 2011. The customer experience: a road-map for improvement. Manag. Serv. Qual. An Int. J. 21, 5–24. doi:10.1108/09604521111100225
Jüttner, U., Schaffner, D., Windler, K., Maklan, S., 2013. Customer - service experiences: Developing and applying a sequential incident laddering technique. Eur. J. Mark. 47, 738–769. doi:10.1108/03090561311306769
Keller, C., Schlegel, T., 2019. How to get in touch with the passenger: Context-aware choices of output modality in smart public transport, in: Proceedings of the 2019 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2019 ACM International Symposium on Wearable Computers - UbiComp/ISWC '19. ACM Press, New York, New York, USA, pp. 982–990. doi:10.1145/3341162.3349321
Kuniavsky, M., Goodman, E., Moed, A., 2012. Observing the User Experience: A Practitioner's Guide to User Research, 2nd ed. Morgan Kaufmann.
Lenz, E., Hassenzahl, M., Diefenbach, S., 2019. How Performing an Activity Makes Meaning, in: Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems - CHI EA '19. ACM Press, Glasgow, UK, pp. 1–6. doi:10.1145/3290607.3312881

Long, T., Johnson, M., 2000. Rigour, reliability and validity in qualitative research. Clin. Eff. Nurs. 4, 30–37. doi:10.1054/cein.2000.0106
Lyons, G., Jain, J., Weir, I., 2016. Changing times – A decade of empirical insight into the experience of rail passengers in Great Britain. J. Transp. Geogr. 57, 94–104. doi:10.1016/j.jtrangeo.2016.10.003
Mackrill, J., Marshall, P., Payne, S.R., Dimitrokali, E., Cain, R., 2017. Using a bespoke situated digital kiosk to encourage user participation in healthcare environment design. Appl. Ergon. 59, 342–356. doi:10.1016/j.apergo.2016.08.005
Maria Stock, R., Jong, A. de, Zacharias, N.A., 2017. Frontline Employees' Innovative Service Behavior as Key to Customer Loyalty: Insights into FLEs' Resource Gain Spiral. J. Prod. Innov. Manag. 34, 223–245. doi:10.1111/jpim.12338
Marshall, R., Cook, S., Mitchell, V., Summerskill, S., Haines, V., Maguire, M., Sims, R., Gyi, D., Case, K., 2015. Design and evaluation: End users, user datasets and personas. Appl. Ergon. 46, 311–317. doi:10.1016/j.apergo.2013.03.008
McLeod, R.W., Walker, G.H., Moray, N., 2005. Analysing and modelling train driver performance. Appl. Ergon. 36, 671–680. doi:10.1016/j.apergo.2005.05.006
Miaskiewicz, T., Kozar, K.A., 2011. Personas and user-centered design: How can personas benefit product design processes? Des. Stud. 32, 417–430. doi:10.1016/j.destud.2011.03.003
Miaskiewicz, T., Luxmoore, C., 2018. Facilitating Innovation and Organization-Wide Integration of Personas: An Approach for Linking Users with an Existing Set of Personas. Des. J. 0, 1–13. doi:10.1080/14606925.2018.1492208
Miaskiewicz, T., Luxmoore, C., 2017. The Use of Data-Driven Personas to Facilitate Organizational Adoption–A Case Study. Des. J. 20, 357–374. doi:10.1080/14606925.2017.1301160
Nathanael, D., Marmaras, N., 2018. From the seat to the system: Re-designing a tram drivers' workstation combining technical and contextual aspects. Appl. Ergon. 73, 214–226. doi:10.1016/j.apergo.2018.07.013
Naweed, A., 2014. Investigations into the skills of modern and traditional train driving. Appl. Ergon. 45, 462–470. doi:10.1016/j.apergo.2013.06.006
Naweed, A., Balakrishnan, G., Dorrian, J., 2018. Going solo: Hierarchical task analysis of the second driver in "two-up" (multi-person) freight rail operations. Appl. Ergon. 70, 202–231. doi:10.1016/j.apergo.2018.01.002
Naweed, A., Rose, J., 2018. Assessing technology acceptance for skills development and real-world decision-making in the context of train driving. Transp. Res. Part F Traffic Psychol. Behav. 52, 86–100. doi:10.1016/j.trf.2017.11.003
Nielsen, L., 2019. Personas - User Focused Design, Human–Computer Interaction Series. Springer London, London. doi:10.1007/978-1-4471-7427-1
Oliveira, L., Bradley, C., Birrell, S., Davies, A., Tinworth, N., Cain, R., 2017. Understanding passengers' experiences of train journeys to inform the design of technological innovations, in: Re: Research - the 2017 International Association of Societies of Design Research (IASDR) Conference. Cincinnati, Ohio, USA, pp. 838–853. doi:10.7945/C2R388
Oliveira, L., Bradley, C., Birrell, S., Tinworth, N., Davies, A., Cain, R., 2018. Using Passenger Personas to Design Technological Innovation for the Rail Industry, in: INTSYS - Intelligent Transport Systems – From Research and Development to the Market Uptake. Springer, Helsinki, Finland, pp. 67–75. doi:10.1007/978-3-319-93710-6_8
Oliveira, L., Bruen, C., Birrell, S., Cain, R., 2019. What passengers really want: Assessing the value of rail innovation to improve experiences. Transp. Res. Interdiscip. Perspect. 1, 1–9. doi:10.1016/j.trip.2019.100014
Oliveira, L.C., Birrell, S., Cain, R., 2020. Journey mapping from a crew's perspective: Understanding rail experiences. Appl. Ergon. 85, 103063. doi:10.1016/j.apergo.2020.103063
Oliveira, L.C., Fox, C., Birrell, S., Cain, R., 2019. Analysing passengers' behaviours when boarding trains to improve rail infrastructure and technology. Robot. Comput. Integr. Manuf. 57, 282–291. doi:10.1016/j.rcim.2018.12.008
ORR, 2015a. Estimates of station usage [WWW Document]. Off. Rail Road. URL http://orr.gov.uk/statistics/published-stats/station-usage-estimates (accessed 1.29.16).
ORR, 2015b. Statistical releases - Passenger rail usage [WWW Document]. Off. Rail Road. URL

http://orr.gov.uk/statistics/published-stats/statistical-releases (accessed 1.29.16).
Prentice, P., 2015. The pros and cons of Driver Only Operation. Rail 2.
Queirós, C., Fonseca, S., Guimarães, F., Martins, V., 2014. A dimensão do fator humano na segurança ferroviária: estados emocionais do profissional, in: Lourenço, L. (Ed.), Alacafache: 30 Anos Depois. Imprensa da Universidade de Coimbra, Coimbra, Portugal, pp. 33–53. doi:10.14195/978-989-26-1386-4_2
Reason, B., Løvlie, L., Brand Flu, M., 2015. Service Design for Business: A Practical Guide to Optimizing the Customer Experience. John Wiley & Sons, Inc, Hoboken, NJ, USA. doi:10.1002/9781119176541
Rose, J.A., Bearman, C., 2012. Making effective use of task analysis to identify human factors issues in new rail technology. Appl. Ergon. 43, 614–624. doi:10.1016/j.apergo.2011.09.005
RSSB, 2019. Standards catalogue [WWW Document]. Rail Saf. Stand. Board. URL https://catalogues.rssb.co.uk/railway-group-standards (accessed 3.6.20).
RSSB, 2010. Facilitating shared expectations between passengers and front-line staff Final report (T703 Report) [WWW Document]. Rail Saf. Stand. Board. URL https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=16802 (accessed 6.10.19).
RSSB, 2009. Trust and Respect: Facilitating shared expectations between passengers and front-line staff - A report of three case studies [WWW Document]. Rail Saf. Stand. Board. URL https://catalogues.rssb.co.uk/pages/research-catalogue/pb009994.aspx
Ryan, B., Kallberg, V.P., Rådbo, H., Havârneanu, G.M., Silla, A., Lukaschek, K., Burkhardt, J.M., Bruyelle, J.L., El-Koursi, E.M., Beurskens, E., Hedqvist, M., 2018. Collecting evidence from distributed sources to evaluate railway suicide and trespass prevention measures. Ergonomics 0, 1–21. doi:10.1080/00140139.2018.1485970
Salmon, P.M., Lenné, M.G., Read, G.J.M., Mulvihill, C.M., Cornelissen, M., Walker, G.H., Young, K.L., Stevens, N., Stanton, N.A., 2016. More than meets the eye: Using cognitive work analysis to identify design requirements for future rail level crossing systems. Appl. Ergon. 53, 312–322. doi:10.1016/j.apergo.2015.06.021
Salomonson, N., Fellesson, M., 2014. Tricks and tactics used against troublesome travelers-Frontline staff's experiences from Swedish buses and trains. Res. Transp. Bus. Manag. 10, 53–59. doi:10.1016/j.rtbm.2014.04.002
Schmid, F., 2001. Organisational ergonomics: a case study from the railway systems area, in: People in Control. Human Factors in Control Room Design. Institution of Engineering and Technology, pp. 261–270. doi:10.1049/cp:20010473
Shepherd, A., Marshall, E., 2005. Timeliness and task specification in designing for human factors in railway operations. Appl. Ergon. 36, 719–727. doi:10.1016/j.apergo.2005.05.005
Stafford, J., Pettersson, G., Neath, S., 2012. Facilitating shared expectations between passengers and front-line staff, in: Rail Human Factors around the World: Impacts on and of People for Successful Rail Operations. CRC Press, Taylor & Francis Group, London, UK. doi:10.1201/b12742
Stanton, N.A., 2006. Hierarchical task analysis: Developments, applications, and extensions. Appl. Ergon. 37, 55–79. doi:10.1016/j.apergo.2005.06.003
Stanton, N.A., McIlroy, R.C., Harvey, C., Preston, J.M., Blainey, S., Hickford, A., Ryan, B., 2017a. Exploring the Constraints of Modal Shift to Rail Transport, in: Cognitive Work Analysis. CRC Press, Boca Raton : Taylor & Francis, CRC Press, [2017], pp. 207–232. doi:10.1201/9781315572536-9
Stanton, N.A., Salmon, P.M., Walker, G.H., Jenkins, D.P., 2017b. Cognitive Work Analysis: Applications, Extensions and Future Directions. CRC Press, London, UK. doi:10.1201/9781315572536
The Independent, 2017. Rail strike: 2,000 workers undertake industrial action across UK, wreaking travel chaos [WWW Document]. URL http://www.independent.co.uk/news/uk/home-news/rail-strike-train-latest-delays-uk-rmt-action-rail-maritime-transport-union-a7626456.html (accessed 4.3.17).
The Scotsman, 2016. ScotRail strike suspended so 'further talks' can take place [WWW Document]. URL http://www.scotsman.com/news/transport/scotrail-strike-suspended-so-further-talks-can-take-place-1-4192640 (accessed 8.30.16).

Transport Committe, 2016. The future of rail: Improving the rail passenger experience [WWW Document]. Transp. Comm. URL https://www.publications.parliament.uk/pa/cm201617/cmselect/cmtrans/64/6402.htm (accessed 5.4.17).
Turner, P., Turner, S., 2011. Is stereotyping inevitable when designing with personas? Des. Stud. 32, 30–44. doi:10.1016/j.destud.2010.06.002
Venkatesh, V., Bala, H., 2008. Technology Acceptance Model 3 and a Research Agenda on Interventions. Decis. Sci. 39, 273–315. doi:10.1111/j.1540-5915.2008.00192.x
Wilson, J.R., 2014. Fundamentals of systems ergonomics/human factors. Appl. Ergon. 45, 5–13. doi:10.1016/j.apergo.2013.03.021
Wilson, J.R., Norris, B.J., 2005. Rail human factors: Past, present and future. Appl. Ergon. 36, 649–660. doi:10.1016/j.apergo.2005.07.001