HADRIAN gets streetwise

J.M. Porter[a], R. Marshall[a], R.E. Sims[a], D.E. Gyi[b], K. Case[c]

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[a] *Department of Design & Technology, Loughborough University, Leics LE11 3TU, UK*
[b] *Department of Human Sciences, Loughborough University, Leics LE11 3TU, UK*
[c] *Wolfson School of Manufacturing & Mechanical Engineering, Loughborough University, Leics LE11 3TU, UK*

Abstract

HADRIAN is a computer-based inclusive design tool developed initially through the EPSRC 'EQUAL' (Extending Quality of Life) initiative to support the design of kitchen and shopping based tasks. The tool is currently being expanded through the EPSRC Sustainable Urban Environments programme to include data on an individual's ability to undertake a variety of transport-related tasks, such as vehicle ingress/egress, coping with uneven surfaces, steps, street furniture and complex pedestrian environments. A feature of the enhanced HADRIAN tool will be a journey planner that compares an individual's physical, cognitive and emotional abilities with the demands that will placed upon that individual depending on the mode(s) of transport available and the route options.

Keywords: human modelling; inclusive design; HADRIAN; SAMMIE; transport design; journey planner

1. Introduction

HADRIAN (Human Anthropometric Data Requirements Investigation & ANalysis) is a computer-based inclusive design tool that was created through the EPSRC 'EQUAL' (Extending Quality of Life) initiative. The tool has been described in detail in previous publications [1,2,3]. The tool is now being further developed with current funding from the EPSRC Sustainable Urban Environment (SUE) Programme.

Accessibility and User Needs in Transport for Sustainable Urban Environments (AUNT-SUE) is a multi-disciplinary consortium of researchers from London Metropolitan University, Loughborough University, University College London, RNIB, London Borough of Camden and Hertfordshire County Council. The aim of the consortium is to improve our understanding of the needs, abilities and preferences of people who experience transport-related exclusion in towns and cities. Better empathy with disadvantaged users and would-be users will be encouraged through an AUNT-SUE 'toolkit' to support planners, designers, operators, user groups and others working to make urban transport and street design more inclusive.

This paper describes the on-going development of HADRIAN by the team from Loughborough University. This involves data collection from 100 individuals, including those who are older and/or physically disabled. The data collected consists of anthropometry, joint constraints and reach range volumes, which are used within HADRIAN to construct individual virtual human models of all the participants, and physical task capability data (including postures and behaviours) in kitchen-related bend-reach-lift tasks and transport-related stepping up/across and reaching tasks. These behavioural elements allow the tool to predict success or failure of virtual tasks for each of the participants. In addition, a questionnaire is administered in order to discover some of the cognitive and emotional barriers to travel, as well as coping strategies and further details of physical capability (walking, carrying luggage, climbing stairs, and so on). These data will be entered into the existing HADRIAN software, expanding on data collected previously whenever possible, with additional individuals being selected where this is not possible.

2. Inclusive design: moving from a philosophy to design practice

2.1 Inclusive solutions require more than percentile data

'Design for all', or inclusive design, needs to move from being a philosophical viewpoint to being a central feature of design practice. Key to this is establishing empathy between designers (who usually start their careers whilst young, healthy and able) and the people who would primarily benefit who are often older, in poor health and unable to achieve all the tasks they would like to with ease and confidence (if at all).

Current design practice typically involves using anthropometric and biomechanical databases that present percentile values for body size and strength, joint ranges for mobility and so on. These anonymous numbers fail to motivate the designer to vigorously explore design solutions that are more inclusive. Sadly, the commonly accepted view for mainstream design is to cater for only the 5^{th} to 95^{th} percentile users of a product or service. This is designing for numbers, not people. Today, we believe that it is no longer acceptable to continue this approach of deliberate 'designing out' of people who are in the top or bottom 5% of size or ability.

In addition, people can be excluded from using a product or service because of a wide range of factors including their personal cognitive and emotional dimensions. For example, a person may be able to reach a control but not able to manipulate it with sufficient accuracy; able to lift an item but not have the balance to carry it safely; able to see a timetable but not able to plan a journey route; able to walk 100 metres but not confident enough to cross a busy road; able to climb stairs but not willing to walk past a group of teenagers in an environment dominated by graffiti; and so on.

2.2 Brief description of the HADRIAN inclusive design tool

The AUNT-SUE project has enabled us to continue developing HADRIAN. The current prototype tool includes the following features:

a) detailed information on the size, shape, abilities and preferences of a wide range of people, each presented as individual datasets (see Figure 1). This information comes as a set of screen displays for each person, including video clips showing them undertaking a variety of tasks such as lifting a baking tray with oven gloves on, reaching to food stuffs on a low or high shelf etc. These data are both informative and foster empathy between the designer and these future users/consumers. Basic cognitive and emotional data related to 'activities of daily living', such as shopping, cooking and making a journey, are also included. Each individual's anthropometric and biomechanical data are used to specify individual SAMMIE human models.

b) a simple task analysis framework whereby the designer can specify a series of task elements (such as look at, reach to, lift to, walk to, climb up) with reference to physical items in a CAD model of an existing product or a early prototype of a new design.

c) an automated analysis whereby each individual in the database is assessed in terms of their ability to complete successfully each task element. This procedure deals with the multivariate nature of interactions with products, integrating the relevant physical, cognitive and emotional issues.

d) those people who cannot achieve a critical task element, and are effectively 'designed out', are brought to the attention of the designer – this includes a virtual simulation of the problem(s) encountered by each person. This visualisation of the person and the problem encourages the designer to explore potential solutions by modifying the CAD model and repeating the analysis.

3. Current development of HADRIAN for transport tasks

We are currently expanding HADRIAN to include data on an individual's ability to undertake a variety of transport-related tasks, such as vehicle ingress/egress, coping with uneven surfaces, steps, escalators, lifts, street furniture and complex pedestrian environments. The tool will provide a database of physical, emotional and cognitive information for 100 individuals, carefully selected to cover a very wide range of

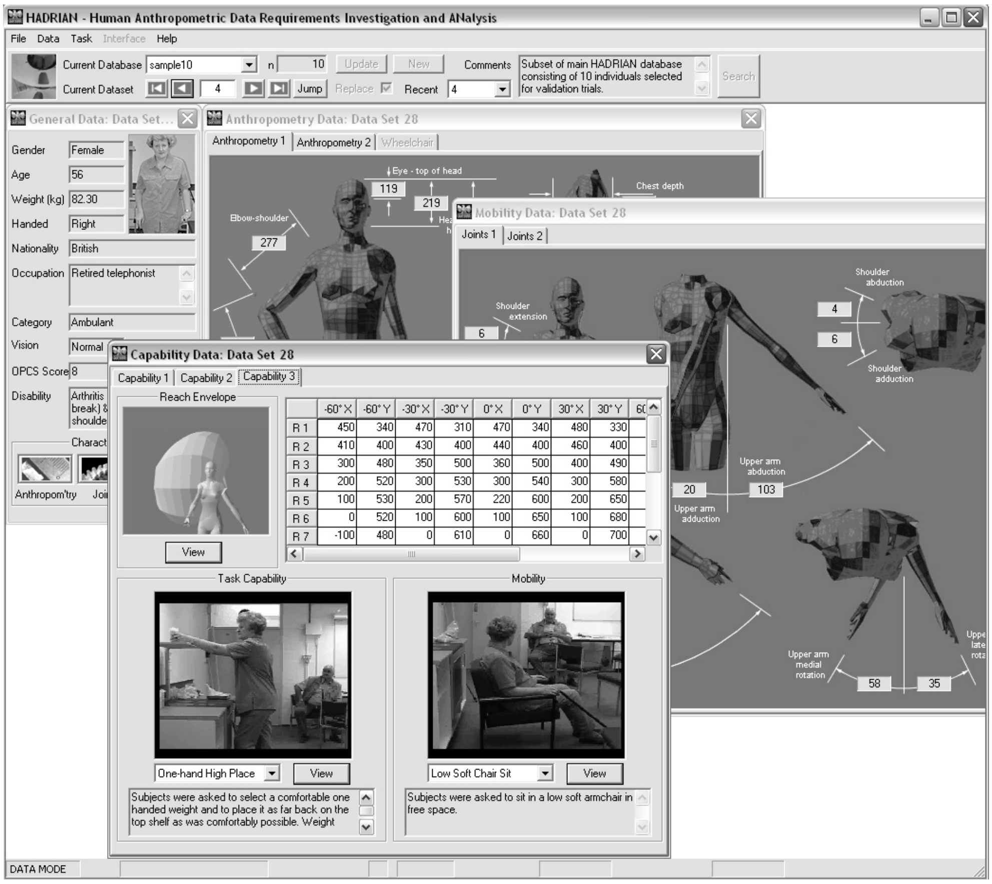

Figure 1: Example of various windows for a specific individual in the HADRIAN database

abilities. This will allow those who are planning, designing and operating transport vehicles and systems to maximize social inclusion and access by considering the issues being faced by the users of public transport as they move to and fro between home, work, education, medical care, leisure and shopping. We plan to undertake some case studies within the testbed areas, or elsewhere if more suitable, where HADRIAN will be used by designers and planners to 'try out' different options for a specific design problem, be it a ticket barrier, a train station or access to the Olympics 2012. The tool should be able to identify the superior design option in terms of inclusivity, and to give direction as to how to improve it further, if appropriate.

Several issues have emerged during this research, some of which are discussed below.

3.1 Participant selection

The complexity of carer interactions was considered too difficult to quantify and model within the current software tool. Consequently, the decision was made to exclude those who are not physically able to get themselves out of their house and onto the pavement to join the transport system. Clearly, such people still have needs and aspirations for transport usage, and a future study could exclusively explore the considerations involved with individuals and carers.

It was our intention to revisit as many of the 100 people who had previously participated in the EQUAL funded project to see if they would be willing to participate again. This would enable some study of the longitudinal aspects of age and disability, due to the number of years since the first study data collection took place. However, several of the original participants have sadly died in the interim and some others are no longer able to get outside without assistance. Furthermore, we have experienced problems contacting many of the remaining participants as their contact details are now out-of-date.

All participants were required to complete a medical screening questionnaire before the trials. Typically, medical screening questionnaires are used to exclude just the type of participants that our research is looking for. It was important that we were well informed of the potential consequences of a participant's current medical condition so that appropriate changes could be taken to reduce any identified risk during the data collection trials. For example, those participants with vertigo/dizziness were not asked to bend low down and those who were epileptic were not body scanned.

3.2 Transport activities questionnaire

A questionnaire was developed to get rich and detailed information regarding a participant's physical abilities, and also to tap into their cognitive and emotional issues surrounding transport usage. Participants were asked questions concerning: their physical abilities, based on the Office of Population Censuses and Surveys scale [4]; transport usage for trains, buses, trams, London-style taxi cabs and minicab taxis; walking distances, as well as issues surrounding taking luggage on the different transport modes; the types and frequency of journeys made; stairs, lifts, escalators, and timetable usage. The questionnaire also included a request for information about problems experienced in the local area. Any local areas that participants identified as causing problems when travelling will be visited by the experimenters to provide quantitative data to supplement the reports from the participants. In short, the questionnaire aims to provide information concerning issues that may arise at any point during the whole journey process - from leaving home, travelling to a transport node (i.e. a bus stop or station); vehicle ingress/egress, changing transport modes and arriving at the destination.

3.3 Vehicle ingress and egress

When making a journey using public transport a person might expect to be met with a variety of step heights and handle locations during ingress and egress. A rig has been designed to assess participants' abilities in these situations, and decisions concerning which heights and handle positions to study were made after referencing the relevant public transport regulations and making field observations within the Midlands area of the UK.

Train carriages and trams are covered by the Rail Vehicle Accessibility (Amendment) Regulations [5].

Figure 2: Photograph of the ingress/egress rig

This states the maximum step height should be 200mm with handrails placed internally, on either side of the external doorways, between 700mm and 1200mm above the floor. From our observations it was found that step heights into trains varied between 180mm and 280mm, with the one example of trams having no step at all. London Underground state that the maximum step height on their lines is 240mm. Buses and coaches (carrying more than 22 people for public usage) are covered by the Public Service Vehicle Accessibility Regulations [6]. This states that the maximum step height from pavement to bus should be 250mm, with the first handrail inside the bus being within 100mm of the entrance and between 800mm and 1100mm above ground level. Observed step heights for buses were found to vary between 170mm and 300mm, and for coaches between 270mm and 370mm.

The rig, consisting of an entrance and exit, was designed to provide different 'door' widths on each side: one side narrower to simulate an older-style bus, train or coach entrance, and the other side wider to simulate the access of newer buses and trains (see Figure 2). The grab handles on each side can be placed in two positions; on the narrow side they can be set at 100mm or 200mm from the entrance to the 'vehicle', on the wider side they can be set at 300mm or 400mm from the entrance. The step heights can be varied from 150mm, 250mm or 350mm to reflect the worst-case scenario. There is a 100mm horizontal gap between the ground and the 'vehicle' on both sides to reflect the horizontal gap between pavement/platform and the body of the vehicle.

The design of the rig raised a number of ethical considerations. In order to keep the trials as safe as possible, participants completed the transport abilities questionnaire before attempting to use the rig, thereby giving advance information of what would be likely to cause problems. The initial rig set-up was then adjusted according to these responses: able-bodied participants had both step heights set at the maximum 350mm, with handles set at 200mm and 400mm respectively. Less able participants had lower step heights and handle heights adjusted to their ability. When the rig was set correctly, participants were first asked to observe an experimenter demonstrating the task. Experimenters stood on both sides of the rig to offer assistance if required, and it was reinforced that participants should only attempt if they were happy to do so and they should take their time. When it came to stepping down participants were asked to first look at the required step and state whether they were happy to continue, before doing so in a controlled, safe manner. Anyone who felt unsure about the task was obviously free to stop, and steps could be removed if required during the trial.

3.4 Use of whole body scanned data

We are using a whole body scanner ($[TC]^2$ NX_{12} Body Measurement System) to quickly collect body dimensions for use in constructing virtual human models of individual participants (see Figure 3). Participants undress in an enclosed private cubicle into lightweight and close-fitting clothing that is neutral to their skin tone, as high contrast with skin tone causes problems in attaining a complete scan. Once inside the scanner booth participants stand and then sit in standardised postures. The scan takes a matter of seconds, and then the person can exit and dress again.

Traditional external anthropometric data were collected to enable comparison with measurements from the scanner to see if the scanner made the process quicker and more accurate for both able-bodied and less able participants. This comparison is on-going as the trials have only recently started. We have concerns

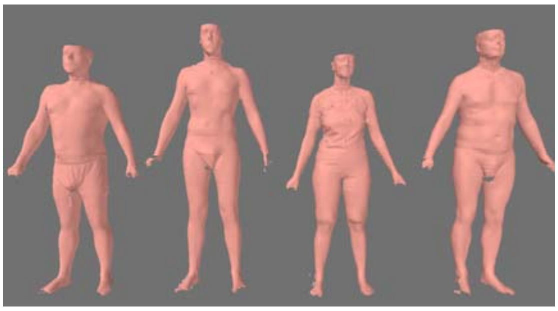

Figure 3: Body scanned images

that less able participants might experience problems getting into the required positions, and there are issues concerning those in wheelchairs, as the scanner dislikes reflection or high contrast, so a 'stealth' wheelchair will need to be designed.

4. The development of a personalised 'journey planner'

A specific feature of the enhanced HADRIAN tool will be a journey planner that compares an individual's physical, cognitive and emotional abilities with the demands that will placed upon that individual depending on the mode(s) of transport available and the route options. For example, some people do not use trains or buses because of difficulties experienced getting on and off, or in getting to their seat before the vehicle moves off; some prefer not to walk through busy public areas or places with graffiti where they feel vulnerable; some experience problems finding their way on unfamiliar routes; some are unable to walk far or to climb steps with confidence; some are reluctant to cross busy road junctions; and so on (see Figure 4).

If a particular desired journey is unachievable or very difficult, either unaided or with support from others, then that person is likely to feel socially excluded. The prototype journey planner should allow people to predict problems that they may experience before deciding to make the journey. Hopefully, a suitable alternative route and choice of transport mode(s) can be identified using the planner such that the task demands fall within the person's abilities.

Whilst the database will only comprise the 100 individuals forming the HADRIAN database, it is envisaged that a web-based planner could be made available. Members of the public would need to complete an on-line questionnaire to provide relevant personal data on their body size (i.e. clothing sizes),

Figure 4: Transport tasks and environments that have physical, cognitive and emotional dimensions for the traveller.

general health, abilities and transport preferences. A major issue in such a planner would be compiling a database of the specific demands that would be placed on the traveller as a function of the exact geographic locations and the transport modes available for a particular journey. It is hoped that a pilot trial can be run in the testbed areas, with transport nodes, shopping areas, museums, theatres, cinemas and restaurants providing data for their surrounding areas (i.e. from the nearest bus stops, train station, taxi rank etc). The data could include, for example, distances by foot, details of steps/lifts/escalators, perceived safety, performance of street lighting/signposting, and quality of the pavement/street surface.

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