HADRIAN: “I am not a number, I am a free man!”

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Abstract:
HADRIAN was created to make a step-function change in the way that inclusive design is accepted and integrated within design practice. Tables of percentile data have now been replaced by holistic databases of individuals covering a wide range of sizes and abilities. Whilst the initial research focussed on physical and behavioural issues related to anthropometry and biomechanics, our current data collection also includes simple emotional and cognitive data within the tool. Details of HADRIAN are presented, including our ‘journey planner’ that is being developed that will compare an individual’s physical, cognitive and emotional abilities with the demands that will be placed upon that individual during the envisioned journey. If the journey is unachievable or very difficult, then that person is likely to feel socially excluded. It is intended that the planner will identify a suitable alternative route and/or choice of transport mode. Designers will also be able to use the planner to assess inclusive design issues for existing and new facilities.

Keywords: inclusive design, human modelling, CAD, task analysis, multivariate analysis, iterative design

Introduction

This paper describes our current research work in adding new emotional and cognitive functionality to our human modelling and inclusive design CAD tool called HADRIAN (Human Anthropometric Data Requirements Investigation and ANalysis). This tool builds upon our 30 years plus experience in developing the SAMMIE system and providing support to a wide range of industrial, commercial and government funded projects through SAMMIE CAD Ltd., an Ergonomics Society Registered Design Consultancy (see Porter et al 1999). As 'expert' users, we have used successfully SAMMIE in a variety of inclusive design projects. However, we felt there was a strong need to empower 'non-experts' so that inclusive design becomes a fundamental part of design practice rather than a 'bolt-on' extra in a small percentage of design projects.

HADRIAN was therefore created, initially, to make a step-function change in the way that anthropometric data are used in the design and evaluation of products and services. Our approach has been to replace numerous separate tables of population percentiles (e.g. for arm reach, hip breadth, sitting height and so on) with a holistic database of 100 individuals covering a wide range of shapes, sizes and abilities. This approach adds significantly to the 'richness' of the data that a designer has access to. Additionally, by presenting the data as individual people the designer has a much greater empathy with those they are designing for. To assist in making use of the data there is a simple task analysis/synthesis tool that allows the designer to simulate various tasks with these individuals interacting with CAD models of equipment and products in the virtual environment. Each task element (e.g. reach to a device, look at instructions) is automatically analysed to identify if any of the individuals have a problem. If specific individuals experience problems, the designer can view these individuals' 'best attempts' to more fully understand the nature of the physical problems with a view to iteratively improving the design and making it more inclusive. Details of our methodology can be found in Porter et al (2003, 2004a, 2004b, 2005), Gyi et al (2004) and Marshall et al (2005).

Although there are a number of inclusive design tools/methods available, none of these include consideration for the emotional issues of users' lives in an explicit manner. We are now adding to HADRIAN's functionality by including additional data concerning an individual's emotional and cognitive dimensions. Our current research is funded by the EPSRC Sustainable Urban Environment programme, and we are part of the AUNT-SUE

(Accessibility and User Needs in Transport) consortium whose aim is to improve our understanding of the needs, abilities and preferences of people, both physical and emotional, who experience transport-related social 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.

Problems with percentiles

'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 frequently involves using anthropometric and biomechanical databases that present percentile values for body size and strength, joint ranges for mobility and so on. These numbers do not motivate the designer to vigorously explore design solutions that are more inclusive. In fact, 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.

Furthermore, people can be excluded from using a product or service because of a wide range of factors including their personal emotional and cognitive dimensions. For example, a person may be able to reach a control but not able to manipulate it as required; 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.

The HADRIAN approach

The HADRIAN inclusive design tool includes several features that are briefly described below.

a) Database of individuals

Detailed information is provided on the size, shape, abilities, preferences and concerns of a wide range of people, each presented as individual datasets. Data are collected using a body scanner (see Figure 1 for examples of the output) whilst a variety of experimental rigs have been developed to assess 3D reach volumes, kitchen and shopping tasks, and vehicle ingress/egress. Furthermore, a transport activities questionnaire is used to obtain extensive information about the nature of any problems experienced when making a journey, for example: physical barriers of all types, cognitive issues with information presentation or wayfinding, or emotional concerns with poor lighting, badly maintained or overcrowded/deserted environments, and so on.

Figure 1: Scanned images for individuals that are used to collect anthropometric data and to construct the matching SAMMIE human models.

This range of information is presented to the designer 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, entering and

leaving a bus/coach/tram/train (se Figures 2 and 3). These data are both informative and foster empathy between the designer and these future users/consumers. Basic emotional and cognitive data related to 'activities of daily living', such as shopping, cooking and making a journey, are also presented. These screen displays are a very useful design resource and we have tried to make them easily navigable and to clearly show the extent of human variability that needs to be considered when practicing inclusive design. The anthropometric data taken from the body scans are used to create virtual SAMMIE human models for each individual in the database, and these are used in the multivariate assessments described below (see Figure 4).

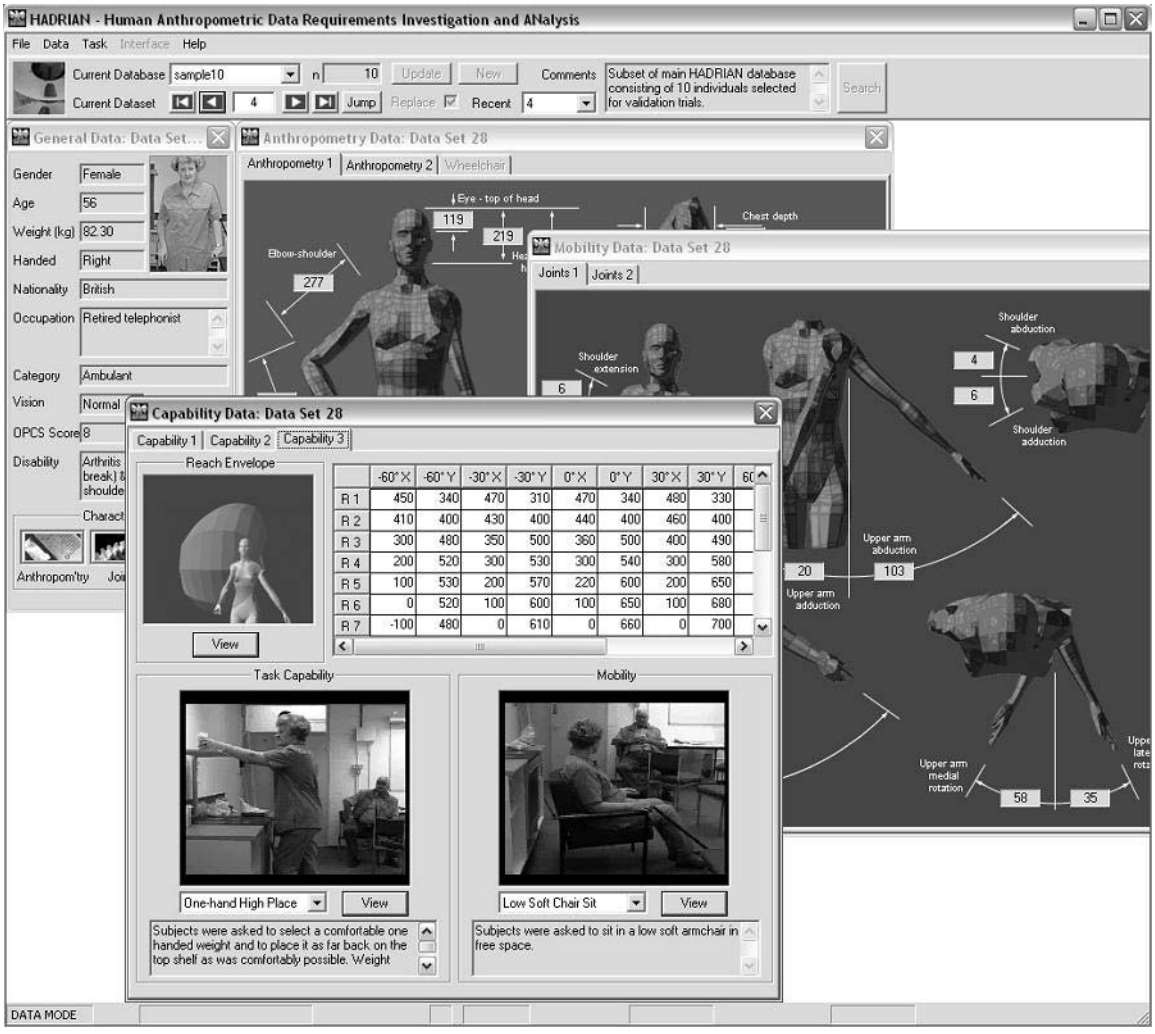

Figure 2: An example of screen displays for a particular individual within the HADRIAN database.

Figure 3: Extracts from video clips for two individuals leaving the vehicle ingress/egress rig.

Figure 4: SAMMIE human models are constructed for each individual in the HADRIAN database.

b) Task analysis/synthesis tool

A simple task analysis/synthesis tool is provided 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. The

designer can specify parameters as appropriate (e.g. thump tip reach for inserting a card into a card reader, required viewing distance for specific character sizes), although the tool will set default settings for each individual otherwise (e.g. preferred hand).

c) Multivariate assessment of each individual's ability to complete a task

An automated analysis can be undertaken 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, emotional and cognitive issues. The physical issues are evaluated using the SAMMIE human models for each individual in the HADRIAN database to create a virtual simulation of the tasks, whilst the emotional and cognitive issues are assessed using personal look-up tables. The analysis presents the percentage of individuals within the database who are 'designed out' from using a product or excluded from using a service, and the designer is encouraged to seek further details by scrolling through virtual simulations 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. The strength of the methodology for the database is highlighted through this process. More traditional methods may provide comparable results, but the designer would only be aware of what percentage of 'faceless' people would not be able to use their design. Using HADRIAN they would be presented with real people, that they already have some empathy with, that they would have to make a conscious decision to exclude from using their design. This move away from purely using numbers (i.e. percentiles) is a key theme throughout our approach.

"I am not a number ...."

Given the above, we hope that the title of this paper *"I am not a number, I am a free man!"* is now more meaningful. The quote is taken from the cult 1960s British TV series 'The Prisoner', starring Patrick McGoohan.

"I am not a number..." HADRIAN does not present people as anonymous numbers in percentile tables (where individuals are lost forever). Instead, individual datasets are presented describing each person in terms of their body shape, size, physical abilities, coping behaviours, cognitive emotional dimensions and cognitive abilities. The designer is, thereby, both more knowledgeable about individual differences and more motivated 'to make a

difference' due to the greater empathy with their problems in interacting with products and services. The interactive nature of the tool allows the designer to view video clips and other personal data for all individuals who are predicted to be 'designed out' from using a product or excluded from using a service. The nature of their predicted problems, be they physical, emotional or cognitive, or a combination thereof, are highlighted for each specific task element. Some people may not be able to climb on board a bus without help, others may be able to get on board but not have the confidence to get to their seat before the bus moves off, and some may be discouraged from using the bus as they know it is 'too' crowded or that the bus stop is in a dark and unpleasant location. In all such cases, people may decide not to use buses at all. The optimum solution to such problems involves both design (e.g. of the bus, bus stop / shelter etc.) and operation (e.g. driver training, scheduling of bus service etc.).

"... I am a free man!" Free in the sense that people want to live independently as long as possible - travelling, shopping, preparing meals and so on are key activities that promote quality of life and social inclusion. Designers have a critical responsibility in this respect and HADRIAN's purpose in life is to support this freedom.

Developing HADRIAN's emotional and cognitive dimensions

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, street furniture and complex pedestrian environments. The latter will include capturing an individual's concerns about finding their way during an unfamiliar journey, changing transport modes (e.g. from a bus to a train), crossing busy roads, walking past large groups of people and/or graffiti and so on.

Our 'Transport Activities Questionnaire' has been developed to get rich and detailed information regarding participants' physical abilities, and also to tap into their cognitive and emotional issues surrounding transport usage. Participants are asked questions concerning: their physical abilities, based on the Office of Population Censuses and Surveys scale (Martin et al, 1988); any problems encountered when using trains, buses, trams, London-style taxi cabs and minicab taxis; their ability to walk distances, as well as issues surrounding taking luggage on the different transport modes; the types and frequency of journeys made; problems in using stairs, lifts or escalators; and difficulties in understanding timetables and

signs. The questionnaire also includes a request for information about problems experienced in the local area. Any local areas that participants identified as causing problems, when travelling, are visited by the experimenters to provide quantitative data to supplement the reports from the participants. For example, this may range from measuring the force required to open a heavy shop door, to assessing the cognitive and emotional issues at a transport node (e.g. changing from a bus to the train, involving crossing busy roads, walking through empty or crowded public spaces with poor street lighting). 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; vehicle ingress/egress, changing transport modes and arriving at the destination.

The tool will provide a database of physical, emotional and cognitive information for 100 individuals, carefully selected to cover a very wide range of abilities. Whilst such data can be obtained traditionally from user trials, this can only be done for existing designs or those at the full-size prototype stage. HADRIAN's database will allow access to this rich data at a much earlier stage in the process. This will, therefore, allow those who are planning, designing and operating transport vehicles and systems to maximise social inclusion and access through the earliest consideration of the issues being faced by the users of public transport as they move to and fro between home, work, education, leisure and shopping. To validate the approach we plan to undertake some case studies within the testbed areas identified by the AUNT-SUE consortium, 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.

A specific feature of the enhanced HADRIAN tool will be a journey planner that compares an individual's physical, emotional and cognitive 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 because of difficulties experienced getting on and 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 5).

Figure 5: Examples of transport tasks and environments that have physical, cognitive and emotional dimensions for the traveller.

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 and preferences.

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), 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, performance of street lighting/signposting, quality of the pavement/street surface, and perceived safety (e.g. ratings from a sample of people covering a range of ages and abilities) and objective safety (data on thefts, accidents, incidents etc).

Concluding remarks

It is hoped that inclusive design tools such as HADRIAN will lead the way in integrating inclusive design within contemporary design practice. To have the greatest impact upon the quality of peoples' lives, it is important that such an approach is adopted by the majority of design professionals. Currently, inclusive design is practiced by only a few specialist designers/ergonomists who have access to the relevant data and have knowledge of appropriate methods. Furthermore, current practice primarily addresses just the physical issues. The HADRIAN approach provides the relevant data on people of all shapes, sizes and abilities, plus the methodology to predict who will be 'designed out' or excluded from using a particular product or service whether this is due to physical, emotional or cognitive factors. We are not advocating that 'one design fits all', but the needs, abilities, preferences, concerns and aspirations of all people who would want to use the product or service should be considered at the concept stage of design. This may result in a single inclusive solution or in a range of products/services to cater for the various niche markets.

Data collection is planned to be completed by September 2006 with the emotionally enriched HADRIAN database being available in April 2007. Our presentation at Design & Emotion 2006 will demonstrate how the empirical data from each individual is used by the tool when assessing inclusive design issues.

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