Inclusive user research: assessing the value of data visualisation

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Abstract

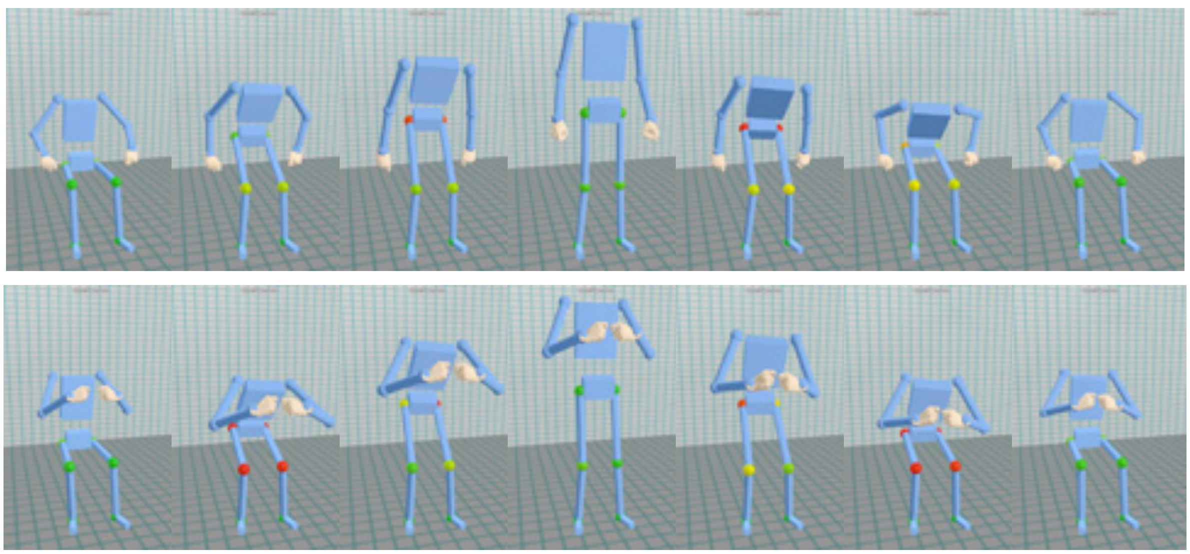
The research evaluated an innovative way of communicating and understanding the complexity of older adult mobility problems using visualisations of objective dynamic movement data. In previous research [1] [2], a prototype software tool was created, which visualises dynamic biomechanical data, captured from older adults undertaking activities of daily living, in accessible way for non-biomechanical specialists and lay audiences. From motion capture data and muscle strength measurements, 3D animated human 'stick figures' were generated, on which the biomechanical demands of the activities were represented visually at the joints (represented as a percentage of maximum capability, using a continuous colour gradient from green at 0%, amber at 50% through to red at 100%). Potential healthcare and design applications for the visualisations were evaluated through a series of interviews and focus groups with older adults, and healthcare and design professionals, and through a specialist workshop for professionals.

1. Objectives

The aim of the project was to evaluate the potential benefits and applications of this innovative way of presenting data in a visual and dynamic format. The objectives of the research were: a) to gather evidence of how the range of stakeholders (older adults, healthcare professionals and design practitioners) interpreted what was being visually represented by the animations; b) to evaluate the potential role of this tool to facilitate cross-disciplinary discourse and deepen professional practitioner understanding; and c) to develop insights about the mobility experience in older adults through empowering them to participate, in discussions with specialists from a range of clinical and design disciplines. At all stages possible, older adults were involved in the evaluation of the tool.

2. Method

A qualitative research approach was used throughout the project: the requirement for improved communication was established through face-to-face interviews, while the tool was evaluated through a Focus Groups (FG) and a Specialist Workshop (SW). Two groups of participants contributed to the interviews and FGs: 1) older adults (N=18); 2) healthcare and design professionals (N=15). For the FGs, older adult participants in the 60+, 70+ and 80+ year old age groups were recruited. Older adults were selected to match as closely as possible the cohort of individuals (and their associated age- and health-related conditions) from whom the original data for the visualisations were obtained. Professionals selected comprised: clinical medicine, physiotherapy, occupational therapy, bioengineering, disability consultancy, engineering design, and interior design. For the SW, a group of 8 professionals, both academic and practitioners who specialise in mobility and ageing, were selected. Interviews (N=33 total) were carried out with professionals and older people. These were recorded, transcribed and analysed using data analysis software. The emergent themes helped inform the content and structure of the FGs where the tool was introduced. Three FGs were held to evaluate responses to the dynamic visualisations: FG1 comprising solely older adults; FG2 with a range of healthcare and design professionals; and FG3 with a mixture of older adults and professionals. Each FG was filmed to support later analysis. In FG1 and FG2, the participants were shown a sequence of animations, without prior explanation, to gain insight into the intuitive understanding of the tool. Animations were selected to show, for example, comparison of two individuals doing the same activity of daily living (ADL) task or the same individual doing the same ADL task in different ways. Discussion was facilitated around semi-structured topic guides to explore the initial responses, the understanding and interpretation of the visualisations, insights they provided, potential applications, and how the prototype might be improved.



Figures 1.1, (top row) and 1.2 (bottom row): Stills from animations: comparison of a 67 year old male with history of back problems and history of fractures performing an activity in two different ways. Figure 1.1, shows him rising from a chair using arm-rests and Figure 1.2 rising from a chair without using arm-rests.

These findings, and a further analysis of the videos were used to structure a facilitated specialist workshop (SW) with professionals (N=8) to explore the potential future development and applications of the prototype, next stage technologies, and implications for future practice, predominantly for healthcare applications.

3. Summary of Key Findings

3.1 The method of visualising the dynamic biomechanical data enables people without training in biomechanics – both professional and lay older people – to

access and interpret the data, thereby improving communication and understanding.

- **It enables lay people to contribute to discussions about biomechanics**: the intuitive understanding of the dynamic visualisations, without preparatory or introductory information, enabled the participants to effectively contribute to the discussion. It was clear that the 'traffic light system' was an effective indicator of the degree of 'pain' or 'stress' being experienced during certain activities, with green indicating 'ok' and red illustrating the 'peak' point. **It allows one to relate to one's own experience and knowledge**: both groups could identify with the movements shown and relate them to either their own personal experience. For example: one of the older people commented: "I see myself getting up and down from the chair"; a design professional made reference to mobility issues he recognised personally, comparing animations of two different individuals conducting the same movement, reflecting age-related deterioration in mobility: "me as a boy … and me as I am now". **It enables new professional insights**: healthcare professionals were able to recognise and compare levels of stress on joints and muscle activity during a full movement cycle, identifying normal and abnormal movement patterns, such as compensations made in the speed and quality of movements that result from mobility problems. **It offers understandable, objective scientific data**: both clinical and design professionals indicated that such a tool might avoid the need to rely on subjective judgement, intuitive skill, and trial and error, thereby allowing more accurate diagnosis in a clinical setting on the one hand, and presenting a sound rationale for design approaches on the other.

3.2 Older people are empowered to participate in the discussion of the problems and issues affecting their mobility with a) clinicians and healthcare practitioners, and b) design professionals

- **It improves two-way communication between older adults and health** professionals: it was felt the visual and contextual nature of the animations could help avoid the need for "medi-speak" which was recognised as a barrier to good communication with clients and other professionals. Older participants thought that the animations would be useful to demonstrate and explain mobility issues and to help address "the white coat syndrome", where they may feel intimidated or forget to raise certain issues during a consultation. At the same time, some professionals have difficulty in providing explanations in lay terms, and it was felt that the tool "makes two-way communication very easy", that it "clearly articulates for the health professional and the older person what is going on in the joints". **It elicits expression of mobility issues**: comments from participants in the older people's focus group revealed that the mode of visualisation generated empathetic responses. One person who had had two hip replacements and a knee replacement commented: "This represents my experience". Others commented: "that's my knee", and "I see myself getting up and down from the chair". They were able to relate difficulties experienced with day-to-day activities in the built environment such as ascending stairs (requiring handrail support), and difficulties entering and exiting transport.

3.3 Healthcare and design professionals can benefit from enhanced communication across disciplines, allowing a more joined-up approach to healthcare and design planning.

- **It facilitates cross-disciplinary insights**: the effective demonstration of sequential movements and immediacy of client feedback were features identified as facilitating the exchange of information. It was felt that viewing the animations together with professionals outside their own disciplines helped provide insights into the other professions: “a simple animation allowed open dialogue between a few different professionals, again the animation is objective and acted as a focus to discuss mobility. It appealed to everyone in its own particular way and wasn’t a tool that in any way isolated the viewer.” **It helps overcome problems of terminology**: the tool helped to overcome barriers that result from variance in terminology used by different disciplines. It also avoided the need for specialist knowledge to interpret traditional data sets. One example was the need for arms on chairs. The animations of an older adult sitting-to-standing-to-sitting immediately illustrated the differences in stress on hips and knees when comparing the use of arm-rests with not using arm-rests. A bioengineer could discuss this in terms of functional demand, a physiotherapist in terms of movement and rehabilitation strategies, a designer in terms of seat and armrest height, and an older person in terms of the impact of mobility related to stiffness, pain or achievement.

3.4 The visualizations allow a deeper understanding of the issues within professions, both in healthcare and in design.

- **It improves over existing techniques**: the tool was considered superior to video techniques currently used during some physiotherapy approaches. The animations objectively illustrated where stresses occur, reducing dependence on intuitive interpretation and subjective judgement, which can result in misdiagnosis. Professionals also felt that these benefits would be enhanced as data were specific to each individual. **It has educational value:** some professionals commented that it had been educational to view the tool, and that they had learned that mobility issues are not restricted to isolated joints: they had not previously considered the sequencing of movements and that as a result of the visualisation this was something they were now more curious about in relation to their practice. **It has ergonomic applications:** one proposal made by the design professionals was for the tool to be used for architectural applications and product development to objectively test the ergonomics of seating, interiors, and products rather than relying on trial and error, as is currently the case with the use of prototypes. **It facilitates an understanding of differences between individuals**: it was suggested that the tool clearly demonstrated the variance in capacity of different individuals conducting the same task e.g. in rising from a chair, bending or climbing stairs, or the same individual conducting a task in different ways, reinforcing, in terms of the design of products and environments, the limitations with standardised approaches.

4. Implications and applications of the findings

4.1 There is potential to improve the uptake and integration of biomechanical expertise and understanding into design and healthcare practice.

The field of biomechanics is well established but it has, until now, failed to impact as anticipated in the fields of healthcare and design. Currently, biomechanics is firmly locked into the domain of scientists and engineers, utilising numerical data and graphs to express and analyse data sets. The profession would benefit greatly from more effective strategies and techniques to interface with clinicians and patients to assist with making treatment choices; and with designers to contribute to the enhanced design of environments, products and services that address age-related mobility issues.

This mode of visualising animated data has demonstrated that biomechanical data can be 'unlocked', shared, aid understanding and inform practice. While recognised as having limited application as a stand-alone tool, as part of a range of healthcare assessment techniques, such a tool could provide a more holistic approach to clinical assessment, diagnosis and rehabilitation. In a design setting, a tool of this nature could be used to, e.g., improve designers' understanding of the importance of ergonomics of products, and in enhancing space design and standards, particularly in relation to the ergonomic and functional attributes of products and the built environment. The ease of understanding and interpreting biomechanical information offered by the tool is of value to both the physiotherapist, and the designer in determining safer mobility strategies, and safer seating. For example (Figs 1.1 and 1.2), in rising from a seat without using the arm-rests the demands on the lower limb joints are close to their maximum capacity. It can also be seen that even with the use of the arm-rests, close to the end of rising from the chair and on the beginning of the sitting movement the demands are high at the hip joints. This indicates that any further deterioration in strength at the hip joints may cause problems for this individual, and may cause risk of falls on rising from chairs.

4.2 There is potential to develop the tool, both in terms of a) the data acquired and b) the technologies involved

The Focus Groups, Specialist Workshop and subsequent discussions have led to the identification of a number of possible enhancements and potential applications of the tool. Both clinical and design professionals recognised the potential of the tool within their respective practices: understandably, older people referred only to healthcare applications and not to design considerations.

- **There is a need to increase data acquisition**: suggested improvements to the tool included extending the dataset to include full body measurements as well as including a wider range of daily tasks. **There is a need for more efficient data acquisitions**: to be applicable, particularly in a healthcare setting, data capture has to be quick and accurate and at minimum expense allowing for efficient assessment and patient feedback. **Real-time viewing of patient movement is desirable**: a proposed ideal healthcare application of the tool would involve capturing data from a patient during a consultation. By viewing real-time dynamic data on-screen, an effective and informed two-way dialogue could be achieved between the specialist and the patient. The retention of such data could also be used to track progress in rehabilitation. **The tool would benefit from using new portable technology**: the generic approach and method of dynamic data visualisation has the potential to be advanced through a range of technological options, from full motion-capture laboratory set-ups, to portable wearable wireless technologies for use in a clinical setting and in the home.

4.3 In healthcare, there is potential to develop new diagnostic, therapeutic, communication and education procedures.

Although this tool relied on data derived from relatively healthy and active older adults, during the specialist workshop it was felt that the tool could have a number of applications other than those that had been explored in this project. For instance, in healthcare it would allow improved aetiology, diagnosis, education, communication, and therapy in a number of specific conditions, e.g., in training for falls prevention, stroke, joint replacement and cerebral palsy. It was felt that this could inform, e.g., surgical teams, patients, and their guardians or parents of the consequences of particular procedures, or help guide patients' recovery or rehabilitation through improved understanding of the causes and consequences of certain movements.

- **Assessment and diagnosis**: in clinical assessment and diagnosis, it was felt that the tool would assist in communicating the exact source of pain and allow more accurate diagnosis of the cause of the problem – including determining the extent of an injury as well as how and why, e.g., deterioration had occurred. In addition, the tool offers the opportunity for cross-validation of other assessment techniques. **Therapy and rehabilitation**: it has the potential to be used with patients during assessment and rehabilitation to illustrate where mobility issues occur and how to overcome or avoid them; and for functional assessment, e.g., in the use of prosthetics. It also allows the effectiveness of clinical interventions to be evaluated over time to establish the suitability of a particular clinical approach as well as to monitor patient progress. By increasing both patient and professional understanding of mobility issues, patient motivation could be increased. **Communication:** within clinical practice, it was considered that the tool could enhance patients' understanding thereby forming a therapeutic tool that better empowers patients to assist in their own recovery. **Education**: it was suggested that this tool could be used to inform teaching and clinical practice, e.g., within the teaching of OTs and physio-therapists. **Prognosis and aetiology**: in the longer term, with the generation of volume data sets, it may be possible to pre-empt degradation and identify signifiers of future conditions to inform healthcare strategies to limit further impairment for patients. In addition, the opportunity to explore the cause of such conditions is presented.

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