

Art and Design Research Centre

Design 4 Health 2013 Exhibition

Sheffield Hallam University



**Sheffield
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Art and Design
Research
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Design 4 Health
2013 European Conference

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The Design 4 Health 2013 exhibition showcases a collection of innovative works that explore the use of creative thinking and practice within the context of healthcare and wellbeing.

Drawing on conventions of both fine art and design, the selected works bring together an informed use of material crafts and processes with the dynamic potentials of digital technologies.

The works are driven by a research agenda that sets out to challenge social, cultural and operational preconceptions around how we think about, manage and engage with contemporary healthcare and wellbeing issues.

Prof. Ian Gwilt

Contributing artist/designers:

Sonja Bäumel | Rémi Bec | Tom Bieling | Simon Bowen | Matthew Coombes |
David Cotterrell | Matt Dexter | Mark Fisher | Nurgül Isik | Eunjeong Jeon |
Tara Mullaney | Heath Reed | David Swann | Koutaro Sano | Alison Thomson |
Jonathan West

Exhibition Curators: Ian Gwilt & Jackie Leaver

Design 4 Health
2013 European Conference

crocheted membrane

Crocheted membrane is part of Sonja Bäumel's thesis project: *"(In)visible membrane: life on the human body and its design applications"*; Design Academy Eindhoven 2009.

A second skin can be found on our skin. It is a layer full of life, which serves as a membrane for exchange. The human body does not end with its skin, but it is invisibly expanding into space. We enter this invisible micro level with a microscope and then enlarge it with design. What happens if we make the micro world of the human body perceivable? How would a piece of clothing, which is defined by personal physical needs or, for example, our body temperature look like?

The crocheted membrane translates scientific data into crochet pieces representing a design language in-between science and fashion design. This project is a visualisation of how we could use our unique bacteria population to create new clothes that would react to our individual body temperature. The texture would get less thick on areas where we need less warmth and would built up on cold body zones.

Crocheted membrane displays a fundamental change in the aesthetics of clothes. Usually, the conventional production of clothes is connected to some aspects of fashion design history. Opposed to this, the crocheted membrane process had a different starting point: an individual human body and its needs with an outdoor temperature of 10 degrees Celsius. What if our second skin would be able to locally adapt to changing conditions in a flexible and autonomous way? Is it possible that even social integration would become more dynamic due to the adaptation of the outer layer to its surroundings?

This project confronts scientific data and methods with fashion design in order to find a balance between individual identity and the surrounding local environment.

www.sonjabaeumel.at
info@sonjabaeumel.at



Creating engaging games to promote Physical Activity (PA) among young adolescents

Sheffield Hallam University

It is believed that the fun games can provide has the power to engage people for serious purposes. This is why this PhD research looks at creating games that promote PA among young adolescents. Despite the fun and entertaining aspect of games, this research faced a range of issues such as working with young adolescents, the sensitive topic of obesity, and finding out about PA that is something adolescents don't engage with. Therefore fun was also considered in the design process to engage the participants pro-actively in the process.

What is exhibited here are the latest versions of the games that have been tested with end-users as well as a few examples of tools that were used to engage the participants in the design development process. The fun and random aspect of dice was used to generate a brief

around which participants created the game of their dreams but dice were also a way for the researcher to get feedback about earlier versions of the games presented and to stimulate inspiration.

There were also other processes that promoted engagement through the level of details and finishing manifested in the tools (and prototypes). Personas were used to explore the continuous dimension of playing games throughout the end-users' daily life, whereas probes were the basis for focus group discussions and for developing the researcher's inspiration and understanding of the participants' life. Finally making activities were also encouraged as a way to reveal tacit knowledge while stimulating creativity.

remibec@gmail.com



Tom Bieling

Speechless (Applications for the deaf and the non-deaf)

Berlin University of the Arts / Design Research Lab

Four short video clips demonstrate solutions for supporting both deaf and non-deaf communication. The concepts include a mobile alert recognition; an app for immediate line-of-sight signaling; an app for receiving realtime information; and a hardware solution for freehand communication.

All four result from the Project “DESIGNABILITIES – Disability-inspired Interaction”, a participatory project between the Design Research Lab Berlin of Berlin University of the Arts, Telekom Innova-

tion Labs at TU Berlin and the Deaf Institution Sinneswandel.

Main goal of this project is to find ways for enhancing Human-Computer-Interaction (HCI) and Information-Communication-Technology (ICT) by transferring properties and principles from ‘disability’ context into general contexts of communication. Therefore we investigate on alternative interaction techniques inspired e.g. by deaf communication or blind navigation
tom.bieling@udk-berlin.de



Tom Bieling

Mobile Lorm Glove

Berlin University of the Arts / Design Research Lab

The Mobile Lorm Glove is a mobile communication and translation device for the deaf-blind. The prototype translates the hand-touch alphabet "Lorm", a common form of communication used by people with both hearing and vision impairment, into text and vice versa. It provides particularly two innovative ways of

communication for deafblind people: it supports mobile communication over distance, e.g. text message, chat or e-mail, and it enables parallel one-to-many communication, which is especially helpful in school and other learning contexts.

tom.bieling@udk-berlin.de



Simon Bowen, Mark Cobb, Andy Dearden, Helena Sustar, Daniel Wolstenholme, Laura Abbott, Lesley Pollard, Simon Bennett, Claire Snowden, Barbara Mansen, Susan Hampshire, Jacqui Wiltschinsky, Sarah Warr, Clare Henry

Better Services By Design

User-centred Healthcare Design (UCHD)

National Institute of Health Research (NIHR)

Collaboration for Leadership in Applied Health Research for Care (CLAHRC) for South Yorkshire

Better Services by Design is the culmination of a five-year project looking at the application of Design Theory and Practice in Healthcare. User-centred Healthcare Design have experience of what does and doesn't work in designing for, and in, health.

This has led us to some principles that underpin our approach, namely that UCHD is about:

- Designing for people not patients
- Designing with people
- Designing for innovation

Through working with our partners (Chilypep, Sheffield Improving Access to Psychological Therapies (IAPT) service and Doncaster Public Health team as part of Doncaster Metropolitan Council) we are sharing the experience with others and 'testing' certain research questions that fall out of the above principles:

- How human-centred is what is designed?
- Do our methods engage and transform stakeholders and communities?
- Do the methods encourage creative thinking

with pragmatic impacts?

Starting with experience we have encouraged partners to engage with their key stakeholders and explore possible solutions. We have transformed the narrative experience through making, into accessible forms (theatre, personas) to allow our partners to develop new ideas. We have grounded the ideas in the real world of health and social care to produce pragmatic proposals, owned by the communities that have created them.

You can find more information about UCHD at www.uhcd.org.uk and about the Better Services by Design Project at www.bsbd.org.uk hello@uchd.org.uk

This article/paper/report presents independent research by the NIHR CLAHRC SY. The views and opinions expressed are those of the authors, and not necessarily those of the NHS, the NIHR or the Department of Health.

CLAHRC SY would also like to acknowledge the participation and resources of our partner organisations. Further details can be found at www.clahrc-sy.nihr.ac.uk.



Matthew Coombes

Single Tear Catcher Mahogany, cork, stainless steel wire, satin ribbon

Northumbria University (this piece was created at Edinburgh College of Art, Edinburgh University)

The Single Tear Catcher was based on the experience of shedding a solitary tear at a funeral but through the making and design processes it transcended into a tool that anyone can connect with. It now has the ability to record both positive and negative emotional experiences that an individual feels is significant to them. A single tear can embody so much.

This was one of several outputs from a project designed to encourage a discourse around the often awkward subject of grief, non-therapeutic tools of grieving. I found that people often don't talk about their grief after a certain period of time, largely because it was not seen as appropriate to do so. I hoped to help rectify this feeling of inappropriateness.

Artefacts can be imbued with important emotional experiences of people through an empathic approach.

Now my PhD research furthers an empathic approach while working alongside people with

dementia. I aim to create new, more positive, internal and external perceptions of people with dementia through co-creation, exhibitions and notions of theatricality, particularly improvisation, and narrative. My working title is:

Selfhood, empathy and perception: a design exploration of internal and external perspectives of dementia through creative empathic practices and notions of theatricality and narrative.

Improvisation techniques are often designed to help produce an environment in which it feels safe to be spontaneous and creative. This could prove exceedingly valuable when working with people with dementia. Story making has a very long tradition in human history. It could potentially give insights into an individual's inner world and personal experience. While keeping an open mind about what exhibitions are and how they can be used, they will be key in changing the way many people think about people with dementia. matthew.coombes@northumbria.ac.uk



David Cotterrell

Anesthesia Awareness, Spherical Projection 2013

Sheffield Hallam University / C3RI

This experiment in immersive filming was produced in collaboration with Professor Roger Kneebone (Imperial College) and designers Cian Plumbe and Matthew Harrison. Cotterrell's ongoing research into the relationship between representation and truth lead him to employ spherical filming techniques to consider the patient view during surgical procedures, which they might never consciously witness.

This initial format of the Design4Health conference presentation is designed to facilitate Cotterrell's further experiments into interactive and responsive visual and auditory installations. It is one of a diverse range of outputs produced by group of artists, musicians, social scientists and surgeons exploring the creative potential for surgical simulation as a catalyst for debate concerning ethics, representation and empathy. A multidisciplinary collaborative network has

been established with support from the Arts and Humanities Research Council to generate approaches, which, seek to offer important insights into the complex relationships between surgery and our wider society.

This pilot project took the unusual approach of challenging orthodoxies through interdisciplinary collaboration. The team explored the benefits to be gained by comparing disciplinary methodologies to challenge traditional limitations of communication and empathy. The core project group is led by David Cotterrell (Professor of Fine Art, Sheffield Hallam) and Roger Kneebone (Professor of Surgical Education, Imperial College London). Participants include Liam Noble (Royal College of Music), Gunther Kress (Institute of Education), Cian Plumbe and Matt Harrison (Royal College of Art & Studiohead) and Fernando Bello (Imperial College London).

info@cotterrell.com



Matt Dexter

3D Printed open-source Enzyme Dispenser

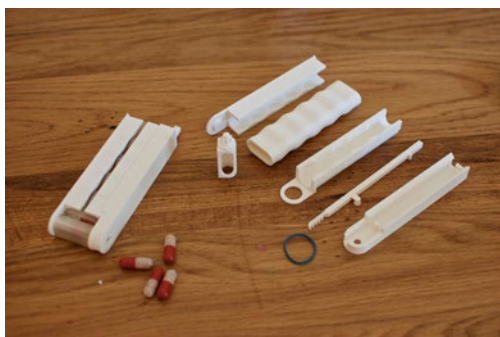
Sheffield Hallam University

This work represents an investigation into the open-source development of medical products. Open-source design (open design) has a similar underlying concept to the Free/Libre Open Source Software (F/LOSS) paradigm; whilst also being facilitated by the Internet, it is also facilitated by digital distributed manufacturing techniques (such as Fab Labs or 3D printers). This allows for diffuse collaboration between participants many thousands of miles apart- indeed; this Enzyme dispenser represents a collaborative effort between people in Arizona, Massachusetts, England, and Washington (to name a few). Open design is not a new idea, with examples of open-source hardware going back as far as the Cornish Tin-Mine Pumps of the British Industrial Revolution. Similarly, notable writers of the 1970s (E.F. Schumacher and Ivan Illich) talked about systems of production and consumption that moved away from a global, dehumanised paradigm to a more local, 'human' scale. These early forbears of open source hardware could not

have predicted the Internet, and it's ability to not just facilitate the distributed development of wholly virtual products (like computer code), but also the production of physical objects. For instance, the raw PLA plastic these Enzyme dispensers are being printed with was made in the UK, from a renewable source. Open design has much to contribute to the collaborative development of products, particularly in the early stages of idea generation.

Open design is particularly suited to medical product design, as people with certain chronic conditions are barred from meeting one another due to suppressed immune systems. This work was done with people who live with Cystic Fibrosis, who cannot even send postal correspondence to one another. Open Design allowed for collaboration in the design process, where previously they were barred from meeting others for participatory design workshops.

Matt.dexter@shu.ac.uk



Mark Fisher

Compact Breath-actuated Dry Powder Inhaler (Patent Pending - GB1219759.6)

Sheffield Hallam University, Art & Design Research Centre

According to figures from asthma charity Asthma UK, 1 in 11 adults and 1 in 12 children are currently receiving treatment for asthma in the UK. Asthma is a relatively common, yet potentially fatal long-term condition, leading to an emergency hospital admission every 7 minutes in the UK. Worryingly however, 75% of these admissions are preventable.

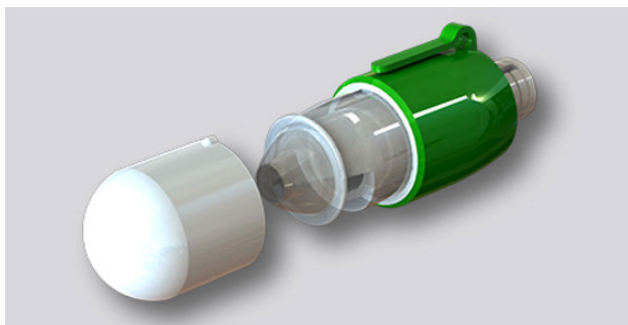
Funded by the Arts & Humanities Research Council, Mark's Industrial Design MA focused on reducing the number of potentially preventable, asthma related emergency hospital admissions. The catalyst for development was the voice of the individual and Mark was fortunate enough to work with a range of design partners living with asthma as well as a team of medical professionals from Sheffield Teaching Hospitals. These first hand insights allowed him to develop a deep understanding of how asthma medication might be re-considered to fit more realistically around people's lives.

Mark identified an opportunity for a more convenient, less-stigmatising reliever inhaler to provide 'just enough' medication in a compact, intuitive and attractive package. Respiratory clinicians and other people living with asthma

have advocated the dry powder device designed in response to this 18-month project. In partnership with Sheffield Hallam University, Mark has filed a UK patent application to protect his novel drug delivery method and we are encouraged to have received the initial examination report with minimal citations. We are currently discussing the concept with various medical product manufacturers, hoping to negotiate a licensing deal to make the product a commercial reality.

The device is a compact and easily transportable breath-actuated DPI, which is simple to use, delivering a pre-metered dose of powdered medication. The inhaler contains five shots stored in the sealed unit and is automatically recharged after each use. This, combined with breath actuation, simplifies the process for the individual, resulting in a more effective inhaler that also reduces problems due to poor user technique. The novel drug delivery method is suited to long-term conditions treatable with powdered medication or the delivery of vaccinations or analgesic drugs and fits well with the changing climate for convenient drug dispensing.

markfisher.design@gmail.com



Nurgül Isik

ROOMI

Delft University of Technology

ROOMI' is an interactive installation that is developed for children with cancer and their families, aiming to support them cope with their emotions during their stay at the Prinses Máxima Center for Pediatric Oncology, which will be built in Utrecht, the Netherlands. 'ROOMI' promotes constructive emotional processing by making it possible to express, externalize and find response to your emotions. Manipulating the pillow-like object creates light effects in real time, which creates different ambiances in the room. The installation is installed in patient rooms and consists of a pillow-like object and a lighting system of LEDs, connected wireless to each other.→ The 'ROOMI' pillow consists of five smaller pillows, each representing an emotion. For each emotion, 'ROOMI' has another goal and function to make coping possible. Each one has its own way of manipulating to create its light effect.

of them has its own way of manipulating and creating a light effect. For each emotion 'ROOMI' has another goal and function to make coping possible. For 'anger' this is mainly expressing your anger with explosive red light and being able to cool down with a slow transition to blue. For sadness and anxiety the goal is mainly creating an environment that is comforting. A serene environment with yellow and white light, should give sad users some space to experience their sadness and maybe even hope. Anxious users should find comfort and feel secure in the environment where the light slowly rocks between green and blue. For boredom and happiness, the main goal is stimulation. Bored users get stimulated to be active again by being able to create different light effects. Happy users are stimulated to celebrate their happiness with a colorful environment changing its colors up-tempo.

The 'ROOMI' pillow consists of five smaller pillows, each representing an emotion. Each one

Nurgulisik5@gmail.com



Eunjeong Jeon, Kristi Kuusk, Martijn ten Bhömer, and Jesse Asjes

Vibe-ing merino wool combined with conductive thread

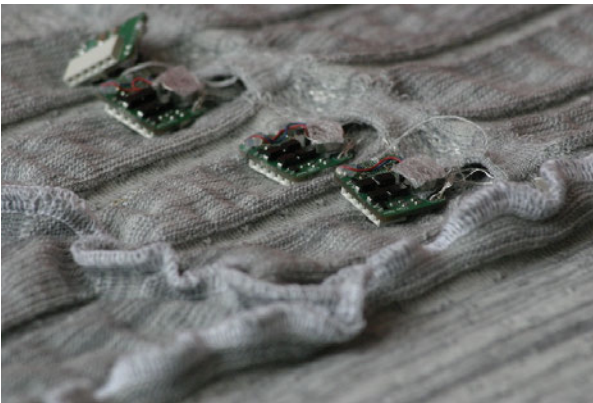
Eindhoven University of Technology, Department of Industrial Design
TextielMuseum, TextielLab, Tilburg

Vibe-ing as a self-care tool invites the body to feel, move, and heal through vibration therapy. Vibe-ing is designed to empower the vibratory energy sharing between the garment and the healing body for older women who are most at risk of developing osteoporosis in the post-menopause period.

In a design approach, Vibe-ing is a knitted and felted wearable textile made out of merino wool and conductive thread using fully-fashioned digital production techniques. The knitting and felting technique to produce the garment results in a soft and bulky surface. This surface invites the wearer to touch, move and feel the fabric and the body, which could have positive effects on the tactile experience. Vibe-ing can be worn in various ways, giving to it the freedom to provide

different stimulation areas on the same garment using technology and resources more functionally and efficiently. The garment contains multiple pockets with modular vibration and sensing (capacitive touch) PCB's, which are connected by power and communication lines. This makes it possible to program the exact areas and form of stimulation on the body, depending on the specific person's need for care, rehabilitation, and healing. The main mechanism to achieve this is the vibration that, transferred by wool, has a healing effect on the bone structure of the people wearing the garment.

This design project, Vibe-ing contributes to the prevention of osteoporosis in order women and therefore supports the need for their wellbeing.
e.jeon@tue.nl



Radiotherapy, one of the three dominant treatment modalities for individuals with cancer, accurately directs ionizing radiation to cancer cells through targeted dosage planning, which is derived from CT images of the tumor. These CT images generate a positional dependency within the dosage planning system, and require that patients are accurately repositioned to their initial CT coordinates for every radiotherapy treatment. Within the current system, the nurses and doctors use various tools, such as fixation devices and laser alignment technologies, to correctly align the patient, while the patient lies still on the treatment bed. Previous research has found that fixation devices have been shown to cause anxiety and emotional distress in cancer patients due to the physical restraint they impose, with this anxiety being partially attributed to the passive role patients must assume while in fixation (Mullaney et. al., 2012). But what if patients could become active participants in positioning their own body?

Here we present our experimental positioning system, building upon the skeletal tracking capabilities of Microsoft's Kinect platform, which offers an alternative to the current standard of care within radiotherapy by engaging the patient as an active participant within the process. By providing patients with the ability to visualize where their body is in relation to the desired position, as well as providing feedback for when these two positions are aligned, we have created an interactive system that provides patients with the ability to accurately place their bodies into the correct position before the nurses fine-tune this alignment. This prototype shifts the enacted roles within the radiotherapy treatment room from the traditional dominant provider/passive patient relationship, to a mutually empowering and supportive one, and provides an alternate view of what patient experiences of radiotherapy could be.

Mullaney, T., Pettersson, H., Nyholm, T., Stolterman, S. 2012. 'Thinking Beyond the Cure: A Case for Human-Centered Design in Cancer Care', *International Journal of Design*, vol. 6, no. 3, pp. 27-39.

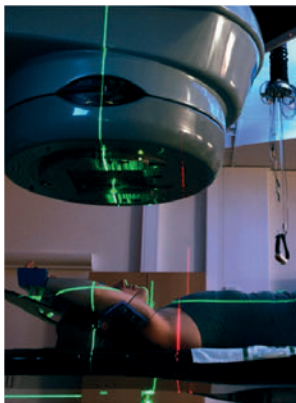
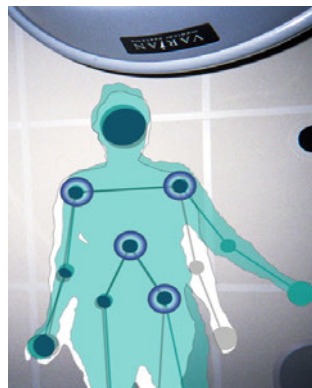


Image of breast board fixation device and laser alignment used for patient positioning in radiotherapy treatment.



Patient self-positioning visual feedback, powered by Microsoft Kinect, superimposed upon the radiotherapy treatment room ceiling.

Heath Reed, Andy Stanton, Joe Langley - Lab4Living, Sheffield Hallam University
Christopher McDermott, Pamela Shaw - SiTraN, University of Sheffield
Nicola Heron - Devices for Dignity, Sheffield Teaching Hospitals NHS
Foundation Trust
Simon Judge - Barnsley NHS Foundation Trust
Ann Quinn - Motor Neurone Disease Association

Head-Up

The aim of the Head-Up project is to develop an orthosis for neck weakness that supports the head whilst allowing freedom for head movements without negatively impacting quality of life.

The work addresses an unmet need identified by people with Motor Neurone Disease (MND) who have progressive neck weakness and for whom current collars are inadequate.

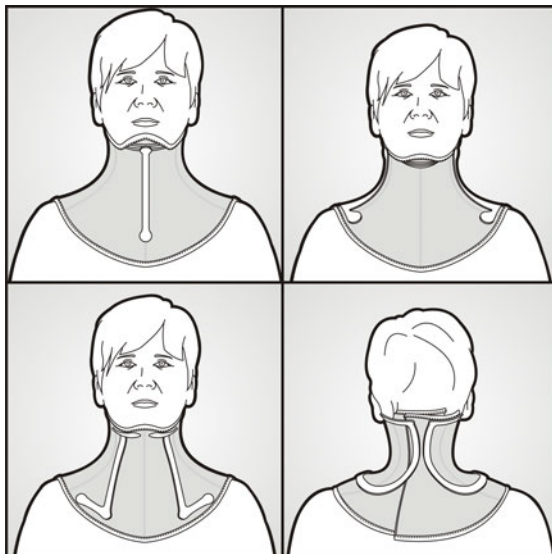
Existing collars provide insufficient support or completely immobilise the neck, either way negatively impacting quality of life. Further, they are awkward to use and aesthetically displeasing. This project brought together MDN healthcare professionals with designers, engineers, people living with MND and carers all of whom have

worked together to arrive at this concept.

The co-design process has involved early prototyping; putting real artefacts into people's hands to elicit feedback. This has been supported by a range of custom 'tools' including a comfort analysis of existing collars, an engineering simulation of a person wearing various collars and EdWood; a mannequin with a weak neck and head drop.

j.langley@shu.ac.uk

This presents independent research commissioned by the National Institute for Health Research (NIHR) under the Invention for Innovation (i4i) Programme. The views expressed are those of the author and not necessarily those of the NHS, the NIHR or the Department of Health.



A behaviour-changing syringe

University of Huddersfield, Design to Improve Life Research Forum

INDEX: Design to Improve Life

Injections- the simplest and one of the most common healthcare procedures performed in the world and for some the most deadly. Each year 16 billion injections are delivered using a pre-used syringe. This action kills 1.3 million patients, accounts for 26-million life years lost and 32% of all new Hepatitis B cases. To prevent such violations in 1986 the World Health Organisation instigated the creation of the auto-destruct syringe. AD syringes have since become a prerequisite device for immunization programmes (95%) but little impact in curative context due to excessive cost (5%). An inclusive two-year study has developed an effective innovation strategy to reduce syringe reuse practices. The outcome of the research is a frugal transformative label technology that synthesizes theories of risk perception, chromism and visual design. Our patented syringe exploits proven technologies popular with food industries: carbon dioxide indicator inks and modified atmosphere packaging. Inside a

nitrogen-filled pack our syringe label remains colourless. Exposure to air activates an o-cresolphthalein ink to rapidly absorb CO₂, to provide a 60 second treatment window before a dramatic colour change- from colourless to red. Primary beneficiaries include patients, families, healthcare providers, federal government and manufacturers in both developing regions and industrialised markets - as a package sterility monitor during the supply chain for or any medical device. Peter Evans, Former Head of WHO Procurement Worldwide and Marc Koska OBE Founder of the SafePoint Trust recognize the significance of our research to patient safety. A new global mandate is presently being drafted by the World Health Organisation in conjunction with the SafePoint Trust that seeks to homogenise the production, safety and quality of future WHO-certified AD syringes and injection devices for safety. This award-winning innovation is included as part of this initiative.

d.m.swann@hud.ac.uk



Koutaro Sano, Ian Gwilt, Coilin O'Dubhghaill,

DataBronze

Japan Advanced Institute of Science and Technology (JAIST), Japan
Sheffield Hallam University, Sheffield, UK.

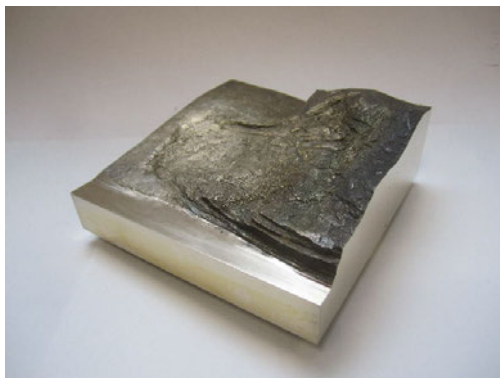
The databronze is a product of a practice-led research methodology that explores the representation of complex statistical information through the construction of physical, three-dimensional objects. The research asks the following three questions, first: can the creation of physical artifacts based on data from scientific sources change the way we read, interpret and respond to complex information. Second: Can data informed objects offer new insight to people outside of the scientific community who do not typically work with or read statistical lists or graphs. And third: What qualities/traits can we capitalize when moving information between digital/material environments.

In this study we worked with packaging engineers who supplied data based on the ability of older people to open ordinary domestic packaging. We then worked with creative practitioners to design objects that represent this data in different ways. Craft making techniques using a range of materials and digitally based processes, such as 3D printing

technologies were explored. The intended outcome of these creative activities was to make as series of object prototypes that could be tested in terms of how they communicated the embedded data. In a user-testing exercise we asked a variety of people to interact with the objects and discuss which objects they thought helped in the comprehension of the original information and why.

Dr Koutaro Sano, a Japanese ceramicist, designer, and researcher interpreted the statistical data as a series of sketches. From these sketches a landscape metaphor was chosen as one of a handful of concepts to be further developed. This landscape metaphor was then used to form the basis of the data-bronze model. In this concept the data drives the topography of the object, with higher numbers corresponding to high 'ground' and lower numbers 'low' ground. Time/age is represented along the sides of the model (young to old), allowing changes in data overtime to dictate the variations in the landscape.

URL research.shu.ac.uk/DataObjects



Alison Thomson, Gavin Giovannoni

Digesting Science (educational programme)

Queen Mary, University of London

Digesting Science is an educational programme where children from the age of six to twelve can learn about scientific research undertaken by the Neuroimmunology Group at Queen Mary, University of London. The programme consists of an educational course for children with parent(s) with Multiple Sclerosis where they can learn about the science behind the condition from the researchers and a website where children can interact with the research themes. The programme is designed to empower and equip young people with the knowledge to deal with the issues of having a parent with MS.

MS clinicians and researchers took part in an iterative process to design tools and activities to communicate scientific information in a way

non-experts could understand, empowering them to engage in conversations and discover much more. Materials like food, water, dominos and electronics enabled metaphors of the body to come to life communicate complex terminology and research topics.

At the course, families meet and interact with clinicians and scientists researching the condition. Topics of the course include "How do you get MS?" "How does MS affect your bladder?" and "How do we treat MS?". After successfully running the programme in Whitechapel over the past six months, the project is currently being developed into an initiative that can be ran by every MS research centre in the country.

Alison.thomson@network.rca.ac.uk



Jonathan West, Grace Davey, Oliver Anderson

The CareCentre: a one-stop shop for commonly used bedside items

The Helen Hamlyn Centre for Design, Royal College of Art

The CareCentre is a unit placed at the end of the hospital bed containing commonly used equipment for bedside care. The aim is to improve safety and efficiency on hospital wards, reducing waste and releasing time to care for the patient.

The concept emerged from in-depth clinical research, taking a holistic view of healthcare processes. The three-year multidisciplinary Designing Out Medical Error project brought together designers, clinicians, psychologists, ergonomists and safety experts to focus on reducing medical error on elective surgical wards through design.

Hundreds of hours' worth of observations and interviews across three large teaching hospitals, consulting over a hundred front line staff, identified typical error prone processes on wards. Failure Mode and Effects Analyses were carried out on specific risky processes, highlighting errors and revealing their causes. Just as the designers were involved in the clinical research, front-line clinicians were

involved in the design process. A breadth of concepts was developed, then iteratively refined. A first prototype was produced, which initially hooked over the end of the bed. A manufacturer was selected, and further development refined the design into the free-standing version now in production.

The design features a much-needed flat surface for reading and writing documents, an alcohol gel dispenser, gloves, aprons, cleaning wipes, a medication locker, a folder holder and a non-touch bin.

The CareCentre is a direct result of the research, and is now commercially available. It has been co-designed with front line staff, and extensively tested both in simulation and clinical trials. Results demonstrate marked improvements in efficiency and compliance with correct infection control protocols. This evidence base validates both the design and the collaborative approach.

jonathan.west@rca.ac.uk



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