Report of EPSRC Rehabilitation Scoping Workshop

[July 2013]

Introduction and Goals of Workshop

A small scale workshop to identify challenges within Assistive Technology (AT) and Rehabilitation was held on the 26 April 2013.

The goals of the workshop were to:

- Identify research activity already on-going in the area of Assistive Technology and Rehabilitation
- Establish a clear view of research gaps and opportunities and also identify where EPSRC might make a contribution

The remit of the workshop was broad covering all types of AT and Rehabilitation. Topics discussed included but were not limited to intelligent orthotics and prosthetics, speech therapy, technologies for assistive daily living. Participants attending the workshop were taken through a series of facilitated activities in order to consider the current research landscape and new or emerging opportunities.

The outputs from this workshop will help EPSRC identify areas in which it is well positioned to make a contribution to AT and Rehabilitation, and will inform the scope of a possible activity in the area.

Attendees

Given that this was a small scale workshop, participants were invited, rather than identified through an open expression of interest approach. EPSRC has tried to ensure a breadth of skills, expertise and organisations were represented at the workshop.

Participants were as follows:

Dr Bernie Conway – University of Strathclyde
Sue Dunkerton – Health Tech and Med KTN
Mr Rama Gheerawo – Royal College of Art (partial attendance)
Professor Mark Hawley – University of Sheffield
Dr Catherine Holt – Cardiff University
Professor David Howard – University of Salford
Dr David Moser – Chas A Blatchford and Sons.
Professor Nick Tyler – University College London

From EPSRC:

Nick Cook – EPSRC
Anna Angus-Smyth – EPSRC
Susan Soulsby – EPSRC
Carol Jones – EPSRC

The Workshop - Outputs

The outputs from this workshop are provided below and each section starts by briefly providing a summary of the activity in which attendees were asked to participate. Following this a short summary which identifies the key points raised is provided. (Full outputs are provided in the Annexes).

Activity 1: What would you like to tell the Prime Minister about Assistive Technologies and Rehabilitation?

Activity
The following scenario was proposed to the participants: ***You are in a lift with the Prime Minister and he asks you "What is the biggest challenge we face in Rehabilitation today?" What will you say in the 2 minutes you have with him?*** **The groups then discussed potential responses.**

Summary for Activity 1

A summary of the key points arising from discussions is provided below, but the full outputs are provided in Annex 1.

- Clear justification for research in this area due to economic, societal and quality of life benefits. In particular, one driver might be research which facilitates and enables individuals, to contribute to and play an active part in society?
- The full breadth of society can require AT and RT (Rehabilitation therapy) – this isn't just an issue that impacts older people. Also of strong relevance to the military, those with diabetes, and those involved in falls or trauma for example road traffic collisions.
- Important to maintain independence of individuals. Avoiding Assistive Technologies becoming the replacement status quo, and avoiding over-dependence on AT.
- Need for multidisciplinary research in this area.
- EPSRC need to consider the wide breadth of the area and not restrict themselves to Rehabilitation and AT for mobility.
- Many challenges around personalisation and 'mass personalisation'
- Habilitation and developing maximum independence in activities of daily living is as important as Rehabilitation.
- Potentially clear benefits from achieving user acceptance of devices through novel / improved design and personalisation. Additionally opportunities around interfaces of technologies (e.g. interface of a prosthetic with the body, or the interface with the environment for smart devices).
- More broadly there is potential opportunities around understanding how we might slow down degeneration as well as restore and recover function

Activity 2:

Activity
Participants were asked to generate a summary of the current research landscape (both nationally and internationally) in the area of Rehabilitation and Assistive Technologies. Where possible, they were asked to identify both topics of research and also where the research is happening. *Note: The purpose of this exercise was not to 'map' the complete research landscape and so there may be omissions. Instead our intention was get participants into the frame of mind were they were considering what research is already going on, as a precursor to identifying gaps and opportunities.*

Summary for Activity 2

A brief summary of research on-going in the community is provided below. Full outputs are provided in Annex 2.

- It is clear that there is a wide breadth of multidisciplinary research going on in the area
- EPSRC need to take care to identify an area where a unique contribution can be made.
- Summarising there is significant research on-going in the following areas:
    - Robotics
    - Novel materials
    - Implants
    - Prosthetics
    - Rehab in the home / Rehab technologies
    - Technologies for assisted daily living
    - Interfaces
        - Neural connections
        - User interfaces for the disabled
- This research targets provision of AT and RT for a variety of impairments including:
    - Visual
    - Speech
    - Cognitive
    - Physical (e.g. upper and lower limb) / mobility

Activity 3: Gaps in the research landscape

Activity
Participants were asked: **"Given the research landscape that you have created, where are the gaps and opportunities for research?"** **Participants were asked to consider the gaps from various different perspectives.**

Summary for Activity 3

A summary for Activity 3 is provided below, but the full outputs are provided in Annex 3.

- Any EPSRC research activity in this area will benefit from input from occupational therapists and hospital based clinical scientists; there is also clear value in input from patients.
- The personalisation agenda is quite prominent; issues here include, 'suitability for purpose', fit & comfort (for example with prosthetics / orthoses), ease of use, and increasing the likelihood of adoption through design & aesthetics
- Measurement, sensing and control also emerge as prominent themes; for example, accurate real time measurements in use, measuring outcomes and effectiveness of devices, and how outputs can be used to determine appropriate dose. Also possible new opportunities in shared control systems, and control systems for advanced devices e.g. in speech therapy. Additionally there is opportunities in developing Intelligent technologies which make device use intentional or intuitive for the user; so that the device 'understands' what you want it to do making use more natural.
- Research challenges around practical requirements such as reducing pain and increasing comfort of AT and RT; novel material developments and design may be able to play a role. For example artificial materials which allow human tissues / bone through e.g. metal attachments for prosthesis which attach into bone. Other examples include bone cements, and joint replacements which include in built sensors to monitor infection/sweating/loading.
- Improved interfaces with the body could play a major role in improving functionality and ease of use of prosthetics making use more intuitive.
- Research and development of upper limb prosthetics appear to have been under-researched and there is space for innovation.
- RT Training aids - In order to improve people's ability to learn e.g. learning to walk again. Devices which provide accurate feedback to the patient about progress and when they are doing exercising correctly.

Activity 4: Overarching Research Themes/Challenges

Activity
Participants were asked: **i) From the gaps and opportunities you have identified is it possible to 'draw out' overarching themes and research challenges?** **ii) What do you view as the priorities a) for EPSRC and b) for multidisciplinary research**

Summary for Activity 4

A summary of the overarching research themes generated by the participants is shown in the table below. Each participant had 2 votes for Engineering and Physical Science based challenges, and 2 votes for the multidisciplinary themes. Further detail and descriptions of each theme are shown in Annex 4.

Overarching Research Themes	Priority in EPSRC remit	Priority Multidisciplinary remit	Combined
1. Technologies that increase therapy and/or care time	2	-	2
2. Outcome measurements	1	3	4
3. Stratification	1	2	3
4. Intelligent Technologies	4	-	4
5. Understanding what people do and what they want to do	-	4	4
6. Digital Assistive Tech – digital Rehabilitation	-	1	1
7. Novel Materials	2	-	2
8. Power Systems	1	-	1
9. Robotics/control and sensors	1	-	1
10. Interfaces	2	-	2
11. Diagnosis	-	3	3
12. Cognitive Prosthetics	-	1	1
[Total]	[14]	[14]	[28]

Observations*:

- Intelligent Technologies emerged as the major research priority within the EPSRC's remit
- While "Understanding what people do and what they want to do" was voted as the major multi-disciplinary research priority
- Outcome measurements and diagnosis have also emerged as themes viewed as important priorities.
- Participants noted that some of the research themes and challenges overlap significantly, or are connected.

**It is noted that the sample size in terms of participants is quite small, and therefore may not be representative of a wider view.*

Activity 5: Research Challenge Exploration

Activity
Participants were asked to look in more depth at these overarching themes, and to carry out a "Challenge Exploration" to scope further detail about the challenge. **Participants were allowed to draw links and connections between themes and were able to bring themes together if appropriate.**

Summary for Activity 5

A summary of the research challenges generated by the participants is shown below. Further details of each of the challenges can be seen in Annexes 5a-c.

- Three multi-disciplinary research challenges have been identified:
  - "Intelligent and Intentional Technologies"
  - "Supervised guided mass Rehabilitation"
  - "Closing the gaps between scientific measurements and clinically useful information"
- "Intelligent and Intentional Technologies"
  - The major challenge here is around how can devices (e.g. prosthetics, orthotics, communication aids or other devices), be better integrated & interfaced to allow accurate function through identifying and interpreting intention from the user?
- "Supervised guided mass Rehabilitation"
  - The major challenge here is around developing devices to support the delivery of accurate, high repetition therapy, which adjusts in accordance to patient progress and needs. The objective being to provide technologies that increase therapy time, whilst minimising contact time with an occupational therapist. For example can we accurately deliver therapy in the home (without a therapist), but also provide feedback mechanisms to both the patient and the occupational therapist?
- "Closing the gaps between scientific measurements and clinically useful information"
  - The challenge here is focused around improving our understanding of scientific measurements, and how they can be translated into clinically useful information. Understanding how this data can then be used as feedback to improve the success of Rehabilitation, determine correct dose and inform personalisation and/or stratification

Conclusion and next steps

Three multidisciplinary research challenges have been identified. EPSRC will continue to appraise these challenges through discussion with the community, with a view to determining the benefit of a potential activity in the area.

At this stage it is clear the challenges identified could all benefit from a multidisciplinary approach; EPSRC's sandpit mechanism is aimed at bringing together people from diverse disciplines to develop research proposals, therefore this would seem to be an appropriate mechanism for a potential funding activity. Furthermore the sandpit mechanism would allow significant user (i.e. patient and clinical) engagement/input, which would benefit research in this area.

Annex 1: What would you like to tell the Prime Minister about Assistive Technologies and Rehabilitation?

Outputs: Group 1

- What is the target for AT/RT (Rehabilitation Therapy)?
- [Re] habilitation – habilitation not re-habilitation?
- What do we mean by 'assistive'? Suggests 'not replacement'
- Exoskeletons
    - Japan
    - Israel
    - EPSRC (Much more interesting)
- Implants – there is funding around but not sure who funds 'new' innovations in the area
    - Cochlear
    - Ophthalmological
- Expectations from RT
    - Impact on recovery/ final outcomes for individual
- 'Value engineering'
- Trans-disciplinarity in AT and RT is expensive *and* essential
- Health economics!
- Changing habits early on children, 30s, and 50s?
    - Early screening and early detection (include children)
    - AT/RT is not just an age related issue!!
- May be a gap in digital (assistive) technologies and 'mainstream' technologies
- We need to be broad and consider not just 'physical' aspects …. social, emotional and personal responses to AT/RT are just as important. For example 'Emotional barriers' to usage / adoption
- AT/RT – aim: to help enough to regain function
- Important to revisit old ideas / concepts where new technologies might increase feasibility
- Long term effects of more people doing sport and picking up lasting injuries early on in their lives?
- Patients as individuals need to maximise what they can do and be in a position to help themselves / live as independently as possible
- Setting targets of capability which are tailored or specific to the individual
- Focus on capability not disability
- Aiming for "normal" is not always the correct Rehabilitation target
- *Personalised* assistive devices
- Optimise prosthesis *for individual*
- Assisting just enough but avoiding dependence

- AT and RT for traumatic events – effective intervention to develop health habits
- Intelligent orthotics and prosthetics
- Early onset of degenerative diseases need to be considered
    - Multiple factors
    - Targeted devices
    - Prevention of degeneration
    - Arresting further development of condition
    - Encouraging compliance

Outputs: Group 2

- Assistive Technology that reduces the 'compensation' on the rest of the body
    - Active people need more hip replacements
- Linking Rehabilitation back to health with preventative Rehabilitation
- Creating wealth through new technology and exports in RT and AT
- Challenge- our ageing workforce
    - Maintaining the workforce through AT and RT
    - Economic argument for investment in the area
    - Financial cost of burden
    - Time bomb of chronic conditions
    - Muscle weakness due to ageing
- Healthier longer life is the goal!
- Powered orthoses/exoskeleton
- Functional electrical stimulation e.g. for foot drop
- What's the appropriate dosage? (e.g. for inflammatory conditions)
    - Time
    - Dose unknown
    - Method of Rehab
- AT and RT assisting with Genetic conditions
- Role of sensory systems e.g. awareness of environment
- Personalisation of Rehab – can we achieve 'mass personalisation'
- Restorative hand movements
- There is a need for AT and RT for BOTH older people and others including the young!
    - Impact on long term care costs
    - Young children - cognitive technologies and activities as they develop
    - Sport – May need to offset problems which occur later in life due to injury
- Spinal cord injury
    - Physical Rehab

    - Build mass
    - Assistive Tech for example wheelchair
- AT and RT Requires a multidisciplinary approach
- Enhancing what you have e.g. lifting technologies
- Rehab process needs to be managed within an appropriate clinical Rehab/environment context
- Assistive Tech important in child development
- Rehabilitation – what does it mean?

    - Restoration of capability
    - Implies some form of recovery
    - Facilities integration to society
- AT and Rehabilitation are different but are used in integrated way…
    - The 'intention' of the technology determines if it is a form of Rehabilitation or AT.
- Assistive Technology
    - Improves quality of life
    - Decreases economic burden
        - Reducing NHS cost
        - Achieving a longer working life
- We need to consider motor sensory / cognitive impairment
- AT - Technologies which assist people to function
    - Including to perform activities *and to be an active part of society*
- Assistive Technologies as a route to slowing the rate of decline
- Effect of Assistive Technologies is broader than just Rehabilitation
    - E.g. in some instances people under recovery set themselves challenging goals such as to run a marathon (where previously they might not have). Psychological / motivational aspects.
- Do Assistive Technologies enable Rehabilitation? - Yes
- Replacements to wheelchairs
    - Walking exoskeletons
    - Industrial interest in this area
- Goals:
    - to achieve a life free from disability and pain
    - Social inclusion
    - Ability to communicate
    - Mobility
    - Cognitive function
    - Social integration
- Measurement base

- AT and RT – not just about enabling mobility - also about sensory and cognitive
- Hand function control of environment
  Loss of function → Rehab → Full recovery
  Not full recovery → Assistive Tech → closer to full recovery
- Prosthetics – prosthetic/stump interfaces
- Why should we fund research?
  - Economic benefits
  - Reduce Burden
  - Improve quality of life ADLs (aids for daily living) – achieving independence

Assistive Tech

- Allows people to do things they otherwise couldn't do

Rehabilitation

- Restores or /recovers function
- OR slow degeneration of function
- OR Prevents loss of function

Applies to all 3 levels of International Classification of functioning (ICF)

- Body Function
- Activity
- Participation

AT & Rehabilitation are different …….but often go together

AT can be in the environment itself, as well as on the person. It can also be an interaction between the individual or technology and the environment.

Personalisation (mass-customisation)

Annex 2: Existing Research Landscape

1. Arthritis Research
   - 1˚care, biotech and Bio engineering , sports, ageing

2. Arthritis
   - ARUK, CRUK, EPSRC/WELLCOME; I.C., MRC

3. EU Funding in assistive devices
   - Robotics
   - Mechatronics

4. Cochlear implants: EPSRC

5. Orthopaedic Implants: much funding – traditional and novel cell based

6. Home care robots (Domestic) – Japan

7. Tele-Rehabilitation – still a new area?

8. Dementia
   - Design Council
   - Nesta
   - How does it relate to ability?

9. Environmental impacts on functional degeneration – EPSRC (a bit) not sure who else

10. In silico modelling; virtual physiological human; lots of funding FP7/EU + EPSRC

11. Research for validation to develop/understand interventions

12. Quite a lot of motion analysis – not enough across disciplines to combine it with bio markers (novel imaging classification)

13. Cell/stem cell based technology for repair and restoration of function: BBSRC/EPSRC/WELLCOME

14. Assisted living - Lots of user-centred design
    - Cambridge
    - Sheffield
    - Helen Hamlyn etc.

15. Microsoft
    - Tools to support visually impaired
    - Mobile solutions

16. TSB - Assisted living platform
    - Dallas
    - Long term care

17. Falls and dementia

- TSB
- Needs to be active not reactive
- UK research

18. Technology for cognitive impairment
    - Sequencing tasks
    - Memory prostheses

19. Voice-output communication aids (more needed)
    - Home control
    - Smart homes

20. User interfaces for severely disabled people
    - Speech recognition
    - Eye gaze
    - Gesture

21. Brain – computer interfaces
    - Europe and U.S.

22. Self-managed Rehabilitation
    - Technology for Rehabilitation in the home
    - Tele-Rehabilitation

23. Rehabilitation using vision technologies/depth cameras e.g. Kinect

24. Serious games

25. Technology for Rehabilitation of speech and language
    - Dysarthria (articulation)
    - Aphasia

26. Rehabilitation robotics
    - Hand
    - Upper limb
    - Lower limb

27. Performance of ADLs
    - Up/down inclines/stats; O&P devices

28. Neural interface control (U.S.)

29. Integrated “limb” research i.e. more than 1 joint

30. Power limb prosthetics

31. Artificial muscles

32. Outcome measurements for O&P

33. Exo skeletal robotics

34. Optimisation/control day/day level

35. Virtual reality; gait training; optimisation of design

36. F&S simulation

37. Rapid prototype technologies

38. Brain machine interfaces (Mainly USA) - Neuro prosthetics

39. Visual prosthetics; hearing prosthetics

40. Neuroplasticity
    - Brain stimulation
    - Robotics
    - Drugs

41. Robotic Exo-skeleton
    - Primarily walkers
    - Not upper limb and not hand

42. Haptics and UR for Rehabilitation

43. Motion capture gaming

44. Prosthetics

    - Intelligent systems
    - System for low income countries
    - Measurement outcome Measures

45. Smart wheelchairs (USA)

46. Joint replacement (materials/bio materials – global

47. Smart materials for AT

Annex 3: Gaps in the research landscape

What are the gaps in the eyes of the NHS? (+ Department of Work and Pensions / Health & Social Care Services)

- Clinical trial mechanisms and ethical approval
- Clinician friendly modular tool kit for bespoke treatment or diagnosis etc.
- Technologies to support increase physio effectiveness and self- Rehabilitation in the ESD and in the community
- Trying to reduce drug/Rehabilitation support bill
- Delivery quality at lower costs
- Lack of therapists – how can you re-map the NHS to cope with less therapists (do things differently)
- NHS looking for the evidence for treatment, outcome for procurement and purchasing – economic benefits (e.g. reducing follow up visits, and increasing benefit gain for patient)
- Lack of use of existing technologies – how to assess "fit for purpose" of prescription and personalisation; actual fit to individual (person)/scanning of the patient site and fit;
- Treatments away from hospitals/tele-medicine
- Avoiding complications/un-intended consequences of care at home e.g. pressure sores from prosthetics
- Building the evidence for new technologies
- Gaps in screening, diagnostics and monitoring – disease understanding, etc. - what are the tipping points for diagnostics?
- Lack of metrics for evidence for e.g. with falls
- Need more clinician/engineer links
- How to evaluate how easy/difficult a device is to use? – How to train patients?
- How can outcomes from devices etc. be measured?
- Health economic research – mapping out interventions and understanding how they impact on economics (longitudinal study)
- Value engineering
- Lack of clinician time or funding for research - have to have collaborations between clinicians and researchers
- Cost effectiveness of solutions/ treatments
- Do devices fit in with NHS structures?

What are the gaps through the eyes of patients?

- Major driver – dignity
- Access to clinical knowledge and skills
- Not getting enough Rehabilitation – what's the 'right' amount
- Personalisation to allow independence
- Comfort and ease of use, musculoskeletal, stroke - dignity and independence
- Faster recovery/motivational component
- Do patients want "self-management" or do they want more clinical support?
- Assistive Technologies from NHS is inadequate/difficult to use/not designed for real world/suitability for purpose
- Practical factors - Less pain, more comfort, less sweat, less inconvenience, easier to put on/take off – comfort at socket interface – military amputees plus others
- Ability to communicate – functional communication and conversation
- Miniaturisation/cosmetic aspects/aesthetics – to increase likelihood of adoption.
- Consistency of support e.g. people visiting home
- Pain and pain management
- Clinician-patient communication - how to get patients to explain what is wrong; training
- Misconceptions, problems with misleading media reports
- Access and diagnosis – non specialist diagnosis tools
- Devices that people are willing to use and be seen using – compliance issues
- Lack of therapy/therapy time – continuation
- Need for simple AT to be better (e.g. crutches)

What are the gaps in terms of science and our knowledge? [What (scientifically) needs to be achieved to address these gaps?]

- What is "normal" within a measurement context?
- What is the "optimum" support from a device to maximise performance?
- Markers for success in Rehabilitation – who will respond to given treatments and who will not?
- How to determine appropriate dose response for Rehabilitation?
- Control systems for advanced devices? – communications, mobility (all)
- Measurement and sensing capability
- Engineering and physical Sciences – intelligence in devices – environmental sensing – communications, smart wheelchairs
- Shared control i.e. between the user and device
- Learning systems – devices which learn user/habits/environment and then adapt to circumstances. How much autonomy to give the device?
- New interface methods – physical – mechanical – computer interfaces?
- Neuroplasticity (systems to promote neuroplasticity – "re-writing" after a stroke, neuro-Rehabilitation. What is the limit of what is achievable?
- How do you quantify/measure Rehabilitation and success?
- Powering devices/energy harvesting and storage – energy density and power
- Implantable systems/bionic integration/e.g. sockets for prosthetics

- Relationship between lifestyle and condition – how do you monitor? (over life course – longitudinal)
- Technologies that support physiotherapists
- EMS and Robotics
- Multifactorial approaches to current condition – how did people get to their current state etc?
- Use of current technologies – how to simplify randomised control trials process?
- Limited/no funding – on outcome measures, impact measures, understanding stratified medicine impacts
- Often basic research underpinning assistive/Rehab research is neglected (e.g. how to measure/assess)
- What is a fall (stumble/trips – not much about "the fall"?
- 1. FES (Functional Electrical Stimulation) as permanent assistive devices
- 2. FES as part of physiotherapy for Rehabilitation (temporary)
- Electrical muscle stimulation (FES) – needs more support and evidence
- Not funded – longitudinal (v. long) studies to understand the pre-factors involved in disease progression and response to intervention e.g. diabetes and heart disease – good screening now and have targeted therapy to control the disease.
- Digital Assistive Technology – very little research
- Autism (adults) – neurological assistance/Rehabilitation – more in U.S. than the UK
- Not funded - condition monitoring; tailored intervention to deal with changing ability/degenerations and recovery;
- Not funded - diagnostics and screening (multiple factors!!) X discipline
- Smart wheelchairs (U.S.)
- Any funding here? – sensors and measurements – a suite of new devices for multiple applications
- Not funded – complex intervention; new interventions; experimental research; X-disciplinary research
- Upper limb prosthetics needs a push – myo-electrics still don't provide functionals of a split-hook
- Powered orthoses
- Active materials/moving away from metals/ materials which behave more like the body, in terms of movements, stretch, weight. – increasing comfort.
- Actuators that perform like muscle
- We don't know enough about clinical needs
    - e.g. for implant/sockets → understanding what's going on internally e.g. with tissue → Is there a safe limit to compress tissue?
- Adaptability within devices → for age of patient and type of use
- Digital health sensors and monitoring
    - Activity profile of people interacting socially
    - How to deal with the information generated?
    - 'Live' measurements in use and then how to change/amend devices to best suit the individual
    - Linking devices to smart buildings/environment technologies
- Tele Rehabilitation → Motivation and feedback change
- Persuasive technologies
- Longitudinal studies
- Collaboration across groups

Annex 4: Overarching Research Themes/Challenges

1. Technologies that increase therapy and/or care time (i.e. amount + quality of therapy)
    - ⇒ E.g. robotic technologies which are capable of delivering OT monitored therapy, within the home based Rehabilitation

2. Outcome measurements
    - ⇒ Ease of use
    - ⇒ Errors – e.g. using an avatar to minimise errors in Rehab therapy e.g. high repetition therapy
    - ⇒ Time to train
    - ⇒ Real World outcome measures
    - ⇒ Pain – (minimisation)
    - ⇒ Function
    - ⇒ Expectations of patient
    - ⇒ Evidence that it's effective
    - ⇒ Evidence of 'level of effectiveness'
    - ⇒ Effectiveness in terms of function
    - ⇒ Cost effectiveness

3. Stratification
    - ⇒ Of diagnostics and condition monitoring
    - ⇒ Understanding history of the condition
    - ⇒ Personalisation to individual

4. Intelligent Technologies
    - ⇒ Intelligent Interface with individual
    - ⇒ Control of device
    - ⇒ Shared control between individual and device
    - ⇒ How to make use 'natural'/realistic/intuitive
    - ⇒ Technologies which learn and improve performance

5. Understanding what people do and what they want to do (for social interactions)
    - ⇒ Environment/smart cities – What role can environment play in Rehabilitation
    - ⇒ Adaptable environments which adjust to needs
    - ⇒ Interaction between personal device and the environment
    - ⇒ How to make the environment an assistive device

6. Digital Assistive Tech – digital Rehabilitation
    - ⇒ Monitoring and bio feedback to clinicians/patients
    - ⇒ New/novel ways of sensory perception
    - ⇒ Including training

7. Novel Materials

- ⇒ Colour change/indicators e.g. for moisture control and @ interface
- ⇒ Materials which behave like skin
- ⇒ Smart and adaptive materials
- ⇒ Sweaty stump materials to reduce sweat build up
- ⇒ Smart materials for Assistive Technology
- ⇒ Bone cements/new approaches
- ⇒ Internally – hydrogels
- ⇒ Externally
- ⇒ Transition interface with skin
- ⇒ Implants
- ⇒ Biomaterials

8. Power Systems
   - ⇒ Power density/energy harvesting/storage
   - ⇒ Devices/implantable/intelligent orthotics and control monitoring devices

9. Robotics/control and sensors
   - ⇒ Sheer Loadings on the body
   - ⇒ Wearable robotics e.g. fitted exoskeleton

10. Interfaces (optimisation for individual – applies to others not just interfaces)
    - ⇒ Human/Brain
    - ⇒ Environment interfaces
    - ⇒ Intention detection 'brain telling device what to do'
    - ⇒ A natural 'go' signal (neural interfaces) to start the device

11. Diagnosis (links to outcome measurements)
    - ⇒ Understanding mechanisms of disease to feedback into therapy diagnostics
    - ⇒ Longitudinal studies
    - ⇒ Informatics relating to effectiveness of treatments and diagnosis

12. Cognitive Prosthetics
    - ⇒ Mood disorders, depression, memory
    - ⇒ Supporting cognitive deficits

Annex 5a : Challenge 1

Intelligent + Intentional technologies

What is the research challenge? What are the specific knowledge gaps being addressed?

- How to make your Assistive Tech an integrated part of "who you are"
- Providing interfaces with devices + accurate prediction of function + identifying intention (for orthotics and prosthetics)
- Improving physical fit/understanding fit – of prosthetics
- Appropriate sensing of the environment e.g. recognition of hot/cold etc wet/dry
- Shared control between device and person
    - Changing minute to minute not month to month – dynamic + constantly changing
    - Continuing changes in the strength of individual (compensating for)
- Sustainable in terms of energy / power. Improved efficiency of device.
- Devices that 'learn' and self-optimise for the individual

Why is it important? How might this impact on Rehabilitation and healthcare? What would success look like?

- If you can sort out fit, intention, shared control we will have people use their prosthetics/communication aid/other Assistive Tech
    - Lower care cost
    - Economics
    - More people in work
- Improving quality of life, in, independence, autonomy
- Dealing with conditions which cannot be treated in any other way
- Technical solutions
- Success = continued use of the Assistive Tech/device

What disciplines should be involved? What expertise / skills / equipment do we need to tackle this?

- Med Eng
- Biomed Eng
- Machine Learning
- Control
- Robotics
- Maths
- Electrical engineers/signal processing/sensors
- Computer Science & AI
- Additive manufacturing/3D print
- Rehabilitation
- End users (patient)
- Neuro Scientists
- Energy

Who are the key people with an interest in this? In academia, Govt., business etc?

- Medical device experts
- Assistive Tech professionals
- Department of Health
- NIHR
- BIS
- TSB
- Military
- Patient Groups

What might make a good Title for this research challenge?

- Assistive Technologies that interface and integrate into you, become part of you
- Intelligent Human-Machine interfacing and shared control, for Assistive Technologies

Annex 5b: Challenge 2

Supervised guided mass Rehabilitation

What is the research challenge? What are the specific knowledge gaps being addressed?

- Using robotics or devices to support high repetition therapy
  - Adapt to your level of ability/strength
  - Safe and easy to use in the home. Useful for movement, speech
  - Adaptable to other patients
- How do we make Rehab accessible with the confines of current NHS practice?
- Using an avatar to deliver Rehab feedback correcting errors
- Improving accuracy/resolution of feedback to patient ad clinic
- Creating motivation, incentivise, adherence to Rehab programme
- Allows (safe) increase of dose

Why is it important? How might this impact on Rehabilitation and healthcare? What would success look like?

- NHS unable to provide intensive Rehab of adequate duration
- Economic benefits

What disciplines should be involved?
What expertise / skills / equipment do we need to tackle this?

- Occupational therapists
- Rehab
- ICT/comp science
- Computer visualisation
- Medical devices

- Robotics
- Software
- Telecoms
- Sensors
- Designers

Who are the key people with an interest in this? In academia, Govt., business etc?

- NHS
- Medical device
- Government
- Independent living
- Stroke patients

What might make a good Title for this research challenge?

- Tele Rehab
- Supervised mass Rehabilitation
- Supervised guided mass Rehabilitation

Annex 5c: Challenge 3

Closing the gaps between scientific measurements and clinically useful information

What is the research challenge? What are the specific knowledge gaps being addressed?

- Determining what data is useful and how to collect it and how to make it useful
- Conformity – longitudinal studies etc
- Disease specific and generic questions – how to determine commonality
- Environment and interactions with environment – effect on person and changes in condition
- How do we make this cost effective?
- How do we have general evaluation methods for AT devices etc?

Why is it important? How might this impact on Rehabilitation and healthcare? What would success look like?

- Routes to personalisation and stratification and better design
- Evidence provides a route to market and creates value
- Providing information for device and technology design
- Integrated approach
    - Devices which are better designed and work → fully evaluated
    - Tools which would enable the outcomes to be achieved from AT and devices

What disciplines should be involved?
What expertise / skills / equipment do we need to tackle this?

- Functional measurements = biomechanics
- Involve clinicians, physiotherapists, engineers (mech and elec + (ivi), social scientists, health economists, biologists, patients etc
- Networks? – Creativity @ home workshops?
- Need more multidisciplinary and ability to communicate between disciplines

Who are the key people with an interest in this? In academia, Govt., business etc?

- Charities
- Biomechanics community, psychology (cognitive), clinical academia, patients
- DoH
- TSB
- Vets
- KTN
- National Stroke Association, TARSAN
- Networks – in Wales etc
- IMechE
- Army
- Sports Science
- Designers

What might make a good Title for this research challenge?

- Closing the gaps between scientific measurements and clinically useful information in:
    - Rehabilitation
    - For stratification/diagnosis/understanding/design of/determining the outcomes of / and evaluating the technology application!
- Outcome Measurements, Stratification, Diagnosis, Understanding what people do