Part 1: Special Thematic Sessions

Special Thematic Session 1
Cognitive Accessibility of Digital Resources

The cognitive accessibility of digital resources is still a major research topic and is insufficiently covered by existing solutions and current accessibility guidelines. People with cognitive limitations can only use digital resources to a limited extent or not at all because they do not understand the available information or cannot orient themselves sufficiently on complex websites. The project Easy Reading tries to solve these problems by creating an environment that allows to adapt the accessibility of websites to the individual support needs of the users. The software framework developed within the scope of the project provides tools for adapting the layout and structure of web pages, for enriching the content of web pages with symbols, images and videos, or for translating web content into a different language level (e.g. plain language or simplified language). In this way, users with cognitive limitations as well as users who have difficulties understanding the original content due to their age, technical experience or migration background can work with the original sources and access all information and services resources. The Easy Reading framework is planned as a cloud based, open source and freely available support infrastructure. In this way, the framework supports the integration and use of state-of-the-art and future research and development. It combines tools for individual user-centric annotation, customization, translation and personalization. In this Special Topic Session the motivation, the project objectives and the current project results will be presented and discussed. Further contributions from similar research projects are also welcome.

Chairs: *Christian Bühler, Ingo Bosse, Susanne Dirks*

GAP REDUCE. A Research & Development Project Aiming at Developing a Tool for Promoting Quality of Urban Life of People with Autism Spectrum Disorder

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Background: The paper reports the first results of a two years ongoing research and development project called "GAP REDUCE" aimed at promoting the possibility of people with Autism Spectrum Disorder (primarily adult and high-functioning) of walking autonomously and safely across the city. The purpose is the design and development of a Web App able to support ASD people to plan, easily and in advance, an urban itinerary towards possible daily destinations. The project is part of a wider research that investigates the specific topic of the relationship between people with autism and the city with the aim of designing an integrated system of urban mobility policies, projects and tools for supporting the real opportunity for them to "use" the city every day. Some considerations motivated the research: the growing incidence of ASD, the almost exclusive focus of existing studies and applications concerning people with autism (mainly children) and space on the design of dedicated, separated, closed and private spaces, and the need of guarantee even during adulthood the actual opportunity to exercise the level of autonomy achieved during educational and therapeutic paths.

Method: The first part of the research dealt primarily on two distinct aspects: one regarding a cognitive framework of autism directed to identify the urban spatial elements that can facilitate or hinder the possibility of ASD people of walking together with the communicative and educational tools to deal with problematic behaviors; the second concerns the design and development of a digital tool, i.e. a Web App, that implements the requirements, assumptions and outputs achieved in the first phase. The App automatically generates routes using spatial elements as waypoints and evaluates these routes suggesting the most suitable path for ASD users. The App is also equipped with a graphic

user interface which permits to show visual instructions on how to overcome situations considered critical (e.g. encountering crowded places, crossing high volume traffic intersections).

A neighborhood in the city of Sassari (Italy) was selected as pilot study area.

Key results: According to the methodological assumptions, during the phases of data collection and first calibration of the algorithm two needs became apparent and influenced the following steps: the necessity to classify the urban spatial elements into two categories: positive and negative Points Of Interest acting as spatial facilitators or obstacles respectively and the need to characterise each POI through a set of attributes to be considered in the evaluation of the most suitable path. Thus three different types of elements have been identified:

a) *POIs* are the spatial features collected and mapped with GIS;

b) *waypoints* corresponding to the positive POIs that are part of the calculated route;

c) *critical points* corresponding to the negative POIs along the route.

The preferable route will be identified initially on the basis of waypoints number and path length, then an evaluation procedure will consider the quality of POIs along the route.

By mean of marker functionality the app will provide a graphical representation of the POIs through texts and images that support the user especially in critical circumstances.

Conclusion: Starting from these first results, a mapping phase will be carried out in the pilot study area with the aim of identifying the spatial elements corresponding to the waypoints and critical points and, in a more advanced stage of the project, a test phase will be carried out with a group of users with high functioning autism.

The functional structure of GAP REDUCE makes it a flexible tool with possible further developments also with respect to the spatial needs of other groups of inhabitants (elderly, people with dementia, people with other sensory disabilities). Beside promoting the autonomy of movement in the city it can also support urban planning processes towards the development of more inclusive and accessible environments for everyone.

Keywords: City and People with Autism, Quality of Urban Life, Urban Capabilities, Web App.

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Cognitive and Learning Disabilities work at W3C and for the Easy Reading Project

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Background: People with cognitive and learning disabilities face a broad range of accessibility barriers in websites and applications. While the W3C Web Content Accessibility Guidelines (WCAG) standard includes requirements ("Success Criteria") that facilitate accessibility for people with cognitive and learning disabilities, the issues and their resolution are often less well understood by designers and developers. Further, many cognitive accessibility techniques require adaptation or personalization by an Assistive Technology (AT), which are not yet well documented. Thus, there is a growing need for a larger corpus of explanatory material and implementable techniques from the W3C Web Accessibility Initiative (WAI), to help minimize these cognitive accessibility barriers.

Method: The W3C Cognitive and Learning Disabilities Accessibility Task Force is developing resources that provide background, requirements, gap analysis, and guidance on designing user interfaces (UI) and content for cognitive accessibility. These supplement the techniques detailed in WCAG. The W3C Personalization Task Force is developing resources for personalized adaptation of content and user interfaces. This allows content marked up with alternative formats to be selected according to user preferences. The EU Horizon 2020 project, Easy Reading, is developing a new Assistive Technology (AT) Framework to provide personalized adaptation for cognitive accessibility. This is will adapt to user preferences with realtime adjustments by monitoring user interactions. As a project consortium partner, the W3C are ensuring harmonization between the project Framework and W3C resources. Any new requirements or techniques uncovered during the project will be included in W3C's resources to maximize impact. In addition, engagement during the project's technical development allows the project's deliverables to benefit from the knowledge already encapsulated in W3C resources.

Key results: The project's Inclusive Participatory Action Research technique and Framework implementation helped improve the W3C cognitive accessibility and personalization resources. This enhanced knowledge may also lead to additional WCAG Success Criteria. The W3C's corpus of cognitive accessibility and personalization knowledge supports sustainability of the project outputs and ensures further dissemination

through integration into existing international standards and supporting guidance.

The Easy Reading Framework is providing a required implementation to validate the W3C techniques in a real world solution. Thus, the W3C guidelines are both distilling new project learnings and also informing the work.

Conclusion: There is a growing awareness of cognitive accessibility user requirements and barriers along with the importance of addressing them at source. Thus, it's an opportune time to be part of the Easy Reading project and to enhance the W3C standards and resources. The Easy Reading project's personalized adaptation framework provides new understanding of user requirements and practical solutions, as well as being as useful Assistive Technology in its own right.

There is now a useful introduction to requirements, enhanced standards, guidelines and techniques that commissioners, designers and developers can use to improve the experience of many.

As a result, the experiences of people with cognitive and learning disabilities can be improved by application of these internationally recognized resources. The W3C operates an open consensus process so others are encouraged to collaborate to further improve cognitive accessibility.

Keywords: Cognitive, personalization, adaptation.

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Inclusive Participatory Evaluation and Analysis with Peer-Researchers with Cognitive Disabilites – an Innovative Approach

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Background: The Project Easy Reading focuses on the individual support needs of the users with cognitive disability while going online. One of the main starting points is the fact that every person is different and therefore needs different support browsing the internet. We believe that a person knows her or his own needs the best and therefore consider people with cognitive disability as experts for themselves They know the barriers they face, so they should be included in research regarding software that is aimed to help people with cognitive disability.

Method: The whole Project is based on a User-Centred-Design (UCD) Approach and includes the Inclusive Participatory Action Research (IPAR). One of the main goals of the project is the combination of these two approaches into one approach: the IPAR-UCD concept. IPAR-UCD describes that the users who will in the end use the software are part of the development of the software.

In the Project 16 Peer-Researchers with different levels of understanding, different level of writing and reading and different level of attention and memory are working in three different organisations taking part in the research process. All three organisations such as Proqualis, DART and PIKSL are participating as partners in the Easy Reading Project. The Peer-Researchers with a cognitive disability are integrated in the whole process of the project.

Key results: After giving a short introduction on the methods used in the project, we will concentrate on some examples of the practical work with the Peer-Researchers: One big part of the project is the User Testing of the Easy Reading Browser Plug-in. The Peer-Researchers are the ones who will carry out the User Testing. For valid and reliable testing, we are working with Test Cases. That means during the project we have to find ways that people with cognitive disability who also cannot read or write are able to work with the Test Cases. We will show the different states of the Test Cases and reflect on the how they were developed in an inclusive team of researchers and peer-researchers. We will outline the iterative way of working in detail and show how it is possible to work in an inclusive team.

Conclusion: Working in an inclusive Team of Researchers and Peer-Researchers based on the IPAR-UCD approach is an innovative way of working in Software Development Projects. Including experts with an own cognitive disability during the development process rises the chances of the acceptance in the End User Group.

Keywords: Inclusion, Participatory Research, Accessibility, Usability.

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Automated Adaptation of Content and Structure of Original Web pages

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Introduction: Creating a good user experience (UX) is key to obtaining and retaining visitors on the web. Countless studies show that for each second your page is in an unusable, unreadable or unresponsive state the drop off rate rises rapidly. Allot of time, effort and money goes into making sure that the UX of a modern website is good, so why doesn't this also always apply to accessibility? One of the main issues with accessibility on the web is the lack of enforcement for accessibility standards within websites. There are guidelines set out by the W3C, such as the Web Content Accessibility Guidelines (WCAG). The 3 levels of these guidelines have only been made a lawful requirement for the public, private or government sector in varying laws within each country, if at all. Even then, if these laws were to apply to all sites it would be an enormous task to enforce it. There are various tools available to check the accessibility of your website however it requires you to use them and then implement solutions to address them.

Methods: With this in mind, how can an accessibility tool be created using a one size fits all solution? It can't. Instead of fully relying on web standards to have been followed we can create engines and algorithms to read the underlying code and structure of a webpage and break this down into various sections. For example, take a typical news article website, we can assume that this will be made up of 3 main sections – the navigation, the content and everything else (comments, adverts, etc.). The user would most likely be interested in the content and navigation so we can use these scripts to adapt this content more suitably for the user. The EasyReading project incorporates peer researchers into a somewhat iterative development process. This allows us to see what areas the end users are having major issues in and adapt or improve the engines accordingly.

Conclusion: Recent advances in technology may be able to help create a state of the art solution. Whilst the development of the EasyReading framework and its engines is still underway, we are looking at how different technologies can be used to automatically adapt and read the content and structure of web pages using Document Object Model (DOM) manipulation, scripting and machine learning. Then look into how to make this content accessible through translation, annotation, and adaption. These engines can then be used within the EasyReading framework to customize a user's experience to their accessibility needs.

Keywords: Accessibility, web, EasyReading, Java Script, Machine Learning.

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Adaptive User Interface Concepts Supporting People with Cognitive Disabilities

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Background: The concept of user interfaces supporting means for automatic adaptation to the requirements, skills or environment of the individual users shows great potential towards enhanced usability and accessibility. Systems that support different user interface concepts and different HCI paradigms enable users with cognitive disabilities to operate them in a familiar manner. This abstract describes how such adaptive user interfaces and interface concepts are developed and evaluated within EasyReading, a framework that allows users to get personalized support for web content in real-time. Framework interfaces and the produced adapted content are directly injected into the web-page, enabling the user to work directly with the original digital content of the page. The resulting architecture adapts to the users' needs in the following ways:

– Presentation of the user interface
– HCI paradigms used to trigger framework functions
– Functions for converting content into an alternative, easier to understand, format
– Presentation of the framework results to the end user

As the architecture is component based, new user interfaces, HCI paradigms and functions can be added and adjusted for the individual user. This abstract should give an overview on the benefits of such an adaptive system as well as its evaluation.

Method: Development within the project is driven by the principle "Nothing about us without us". Therefore, the project cooperates closely with three end user groups from Austria, Germany and Sweden that work as co-researchers in the project in an inclusive ap-

proach. Framework components such as user interfaces and widgets supporting different HCI paradigms are developed together with a single user-group and then tested by the remaining user groups. Based on the outcomes of the testing, the components are refined and further developed until they are approved. Newly developed components are then classified, so that they can be later on matched with a user profile to create solutions for the individual user.

Key results: The first set of components was developed using the aforementioned inclusive approach and the first user tests are ongoing. First results of the ongoing user tests show that there is a strong need for adaptability by the target group. As the abilities and preferences of the user group are divergent, a one-size-fits all approach does not suit. For example, users required different HCI paradigms to be supported when paragraphs present on Web pages had to be adapted for their easier understanding. For some users it felt natural to select the kind of help they would need and then just click on the paragraph, while others preferred to select the text by marking it with the mouse and then clicking a button that would enable the helping functionality.

Conclusion: Adaptable user interface can greatly increase accessibility of systems as they are able to support the different needs of the individual user.

Keywords: accessibility, adaptive user interfaces, people with cognitive disabilities.

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Safety, Privacy and Ethical Considerations when Researching With People with Cognitive Disabilities

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Background: For many people with cognitive disabilities, it's difficult to access the web on equal terms with others. The needs of those who has difficulties navigating and understanding web content are often dependent on context, which makes it difficult to standardize solutions. In the project Easy Reading, peer researchers with own experiences of cognitive disability work together with developers to design a solution to personalize the experience on the web. The question of ethics is essential and concerns both the research process with users and the privacy and security of the technology. The aim has been to produce guidelines on ethical considerations to support the work during the project and to perform a risk analysis to identify and assess ethical risks.

Method: The framework of ethics within the project concerns issues like informed consent, design principles, the role of an ombudsman and personal data. Existing regulations and guidelines and previous research results on this were studied, and best practices on how to research and develop together with the target group were put together. To assess the risks, an ICT risk matrix from Queensland Government was used. It measures how likely the risk is and how serious its impact is and results in a combined risk score, labeled in five steps. All documents will be used as a basis as the project carries on.

Key results: To make sure participants with cognitive disabilities understand the meaning of participating, accessible information sheets and consent forms are important. Such forms were created written in simple language with pictures to support the text.

Basic principles for developing interfaces suitable for users with cognitive disabilities were identified. Systems should be easy to use and allow mistakes and they should be responsive and reliable. Users must be in control of their privacy and systems must comply with data regulations. The role of ombudsman is important to safeguard the safety of participants. It's important that the ombudsman fulfils requirements such as being located in the same area, being familiar with the target group and have legal knowledge. The target group is vulnerable when it comes to understanding and consenting to data collection and their data might be sensitive. Therefore, it's important to only collect the data needed, only keep the data for as long as necessary and only give access to those who need it. The risk assessment includes risks related to the technology and to the research carried out with peer researchers and testers.Checklists focused on the above areas were provided to facilitate practical work.

Conclusion: The question of ethics has to be present where users are involved in the process, and particularly where technology can capture so much information. Data collection must consider the privacy and security aspects. Results from the work done in this project's ethics work package, including practical guidelines and checklists as well as insights into common risks, will be valuable for coming projects, application development processes and user testing within the field of assistive technology.

New Approaches to Web User Tracking

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Background: User tracking in the Easy Reading context differs from the usual understanding of the term as in website visitor tracking (with main focus on marketing purposes). In Easy Reading the focus is on tracking of a user's cognitive load while actually viewing a webpage. Ideally a user needs to make sense of the page on his or her first visit or it might be the last visit. So, in addition to page navigation data through mouse movements and clicks, it will be necessary to introduce additional sensors which can expose certain data on a user's cognitive state.

Method: To solve the problem stated above, first the state of the art in user tracking was analysed. Then current approaches towards the detection of cognitive load were investigated. With certain user-related requirements in mind, like unobtrusiveness, affordability, ease of use and reliability, certain interesting parameters for user tracking in the Easy Reading context were defined.

Key results: The sensors that have been considered most important for future work are eye trackers, fitness trackers and webcams. While the main purpose of eye tracking is to show the user's present point of focus, also additional information can be derived from it. Fixations (200–300 ms or longer) can give an indication of cognitive load when they are long, but come at a low rate. The same applies for Micro-Saccades (fast movements of 30–80 ms in two directions) that come with high velocity and length. A further useful parameter would be pupil dilation, which has long been known to raise on cognitive load. Sadly this can only be measured with professional eye trackers that come at a high price, therefore being in conflict with the requirement of affordability. The purpose of the fitness tracker is to deliver heart rate data. This can be used in two ways: number one the pulse rate itself can help to detect stress (does the pulse raise without the user getting up?) and number two, the Heart Rate Variability (HRV) can be used to measure activity of the autonomic nervous system. HRV is known to respond quickly to changes in a person's cognitive state. Finally, the webcam can be used to detect the user's blink rate, giving an additional indication of the user's state. Specifically when eye blinks come at a low rate and with high latency, it can be an indication of high cognitive load.

Conclusion: All data mentioned above can only be seen as parts of a puzzle. While any isolated parameter will produce many false positives, it is assumed that considered together they will give a more or less clear picture of the user's current cognitive state. This will help to present information in a more adequate way for the individual user and therefore significantly push information accessibility for people with cognitive disabilities, as well as people with other kinds of comprehension problems, like people with a low level of education or people facing a language barrier.

Special Thematic Session 2
User Participation in Software Development

User participation in the development of products and services is generally regarded as one of the key factors for sustainable development. In recent decades, user participation in software development has improved significantly. During software development, users are typically involved in the early stages of development, in requirements analysis and evaluation. Despite this improvement, however, there are still many development phases in which users are not involved due to cost and time constraints, which in many cases leads to limited usability and acceptance of the developed products. Since it is often already difficult to include users without impairments in all phases of the software development cycle, the question arises how user participation is realized in projects in which software products are developed for people with impairments. In the workshop described here, approaches and procedures for user participation of people with different impairments from various research projects, currently funded by the EU, will be presented and discussed.

Chairs: *Christian Bühler, Ingo Bosse, Susanne Dirks*

Participation of Users with Disabilities in Software Development Projects

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Background: Without any doubt, every project manager in software development will confirm that highly usable products can only be developed through active user participation in the development process. User participation is one of the most important factors for project success. In projects where the potential users are involved in the product development, better software is developed and the satisfaction of developers and users with the work processes and the product development is higher. So much for theory – in real life, user participation in software development is somewhat different, especially if the potential user group consists of people with disabilities or other particularly vulnerable people. In addition to insufficient organizational and financial resources, software projects often lack suitable methods and trained developers and interface designers to successfully integrate users with impairments into the development process. In the scope of the presented work, opportunities and challenges of participative software development with people with disabilities were analyzed and discussed and solutions to the most occurring challenges were developed.

Method: In addition to the results of an extensive literature analysis, experiences from various software development projects of the authors were gathered and analyzed, e.g. from the H2020-funded project 'Easy Reading'. Special problems of the different user groups using standard software products, different methodological approaches to user participation and processes of participatory software development projects were analyzed. The systematized challenges and opportunities in participative development projects were then categorized, prioritized and related to different methodological approaches. Based on this, solutions for the most common problems in participative software development with people with different disabilities were developed.

Key results: Most of the common problems in participative software development projects could also be found for the user groups with impairments. However, a number of other problems arose due to the particular characteristics of the respective user groups. For people with motor and sensory impairments, the main problems were the configuration and accessibility of working environments and materials. For people with cognitive impairments, the identified problems were primarily related to the communication within the project, the design of the working materials and the interaction between the project participants. Although agile software development contradicts user-centered development in some aspects, the agile approach with some adaptations proved to be well suited for participatory software development with people with disabilities.

Conclusion: For more effective involvement of users with impairments in software development projects, suitable methods are lacking. The presented work has shown that agile approaches form a good basis for participative software development if they are extended by methods that address the particular requirements of users with impairments.

Keywords: user participation, software engineering, accessibility, agile approaches.

Assistive Technology for People with Profound Intellectual and Multiple Disabilities

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Background: People with profound intellectual and multiple disabilities (PIMD) often communicate on a pre-symbolic level and use unconventional behaviour signals (e.g. specific body movements or vocalizations) to express their needs. The number of those interaction partners who are capable of accurately perceiving and interpreting these specific and highly individual behaviour signals is very limited in most cases. This significantly restricts the participation of this group in all areas of life. INSENSION is an European project focusing on better understanding of the behaviour signals by using the advances of unobtrusive technological recognition tools. Facilitating the communication of and towards people with PIMD could contribute to improve their participation and quality of life. This will be realized by creating a technologically supported responsive environment, which automatically analyses and interprets various behaviour signals against the background of the particular context.

Method: The study has been started with assessing the behaviour signals of six test persons by different methodical approaches:

– based on renowned assessment tools, a comprehensive assessment (questionnaire for their close rela-

tives as well as for direct support professionals) collects information on communication and inner states
– recordings of the test persons using state of the art technology combined with monitoring of physiological parameters by means of the Empatica E4 wristband to analyse facial expressions, gestures, vocalizations and physiological signals
– focus group workshops with close relatives, direct support professionals and IT specialists

Key results: In our presentation, we focus on preliminary findings of the focus group workshops which took place in Poland and Germany moderated according to the Walt-Disney-Method by Dilts (1991) and the additional use of particular methods of the Design Thinking approach like the creation of personas to exemplify the target group. Within the scope of three workshops, the participants defined those situations within the life of people with PIMD, which are most challenging for the target group itself as well as for their direct support persons. Based on the findings of the focus group workshops and based on the collected data of the recordings and the assessment, three applications have been determined to provide technological support. The applications focus on communication, the use of multimedia player and robotic assistance devices. Each application aims to provide remedy in challenging scenarios in order to increase the self-determination of people with PIMD and to improve the quality of their lives.

Conclusion: After the implementation of the main IN-SENSION system in a specific environment, the design process of the determined application is envisaged. Therefore, the inclusion of later users represented by their direct support persons plays an important role in terms of usability since their participation enables an orientation towards the users particular needs and wishes.

Keywords: People with profound intellectual and multiple disabilities, assessment of communication, focus group workshops, information and communications technology.

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Usability Evaluation of Mobile Application for Persons with Disabilities: A Review of Available Tools
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Background: The use of mobile applications is increasing among persons with disabilities (PwD) (Csapó et al., 2015). Apps and mobile devices can represent an affordable assistive alternative to traditional expensive technologies in facing daily challenges (Brady et al., 2013). Therefore, the choice of accessible and usable applications becomes fundamental and must take into consideration the users' specific needs. However, the selection of suitable apps can be difficult, due to their large number rapid growth and development, and because most of them "are untested and unregulated" (Moran, 2018: 10). This requires the identification of specific evaluation tools enabling PwD "to navigate in this evolving app space" (Kim et al., 2018:1). Research in the field has already brought to evidence some of these tools, which investigate the usability of mobile application for PwD (Harrison at al., 2013). Usability, in fact, is based on the user experience design and represents "the extent to which a product can be used by specific users to achieve specific goals with effectiveness, efficiency and satisfaction" (ISO, 1998). The several components of usability can be used to make decisions about the choice of a software (Goel et al., 2018). This study aims at reviewing existing research on tools used for evaluating usability of applications designed for PwD. This will enable the identification of the different components of usability, in order to introduce new tools or guidelines for helping PwD in making self-determined choices.

Method: On 01-22-2019, a literature review was conducted on Science Direct, IEEExplore, ACM Digital Library and Google Scholar to identify primary studies, published from 1998 to 2019. The keywords were "usability evaluation" AND "mobile application" AND "persons with disabilities".

Key results: Thirty prominent studies were found, from which five tools were identified, namely *PACMAD usability model* (Harrison et al., 2013), *Quality criteria assessment scale* (Reynoldson et al., 2014), *Mobile device app evaluation rubric* (Ok et al., 2016), *Subjective Usability Scale* (Reeder et al., 2016), *Health-ITUEM* (Brown III et al., 2018). Each tool is composed of items, grouped in categories, corresponding to usability dimensions defined by the authors. They were applied to evaluate the usability of a certain group of apps (e.g. m-health) and addressed to a specific disability. They are based on different methodologies (yes/no scale, Likert scale, open-end answers) and the assessment was performed predominantly by caregivers, therefore the tools did not directly record the user experience.

Conclusion: This study identified different tools, related to the diverse usability constructs adopted. It emerged their low generalizability and a low involvement of PwD in their evaluation process. Instead, a usability tool that involves direct cooperation with PwD would provide a more insightful assessment. This study highlighted the need of a more thorough evaluation of the importance of the relationship between accessibility and usability in establishing the quality of PwD assistive software. The work also elucidated the necessity to establish regulatory standards, in order to achieve higher quality applications and to promote a universal attitude towards accessibility and inclusion pertaining to PwD.

Keywords: mobile application, usability evaluation, self-determination.

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Inclusive Collaboration in R&D for Improved Cognitive Accessiblity

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Background: e-inclusion entails empowering people to participate independently in digital society including people with disabilities. Usability and User-Experience Design describe user-oriented or user-centered design processes (UCD). The knowledge of UCD is scientifically established and proven for the implementation of assistive technology and e-Accessibility for people with disabilities except for those with cognitive disabilities. So far, there is no full participation of the target group as researchers or experts. Furthermore, there is a lack of methods and tools to support communication and interaction in research and development (R&D). Although there are inclusive research approaches in social sciences, there is still none in the field of software-engineering. In the ongoing Easy Reading Project with the IPAR-UCD concept (a combination of Inclusive Participatory Action Research and User-Centred Design), we demonstrate that adequate attention and the creativity of researchers and developers, as well as the adaptation and (further) development of usability methods and tools, can lead to the inclusion of potential users as peer researchers in user-centered R&D processes.

Method: Development and advancement of the inclusive IPAR-UCD concept are based on the "Design-Based Research" approach. This approach is an independent type of qualitative research methodology. IPAR-UCD was examined and further developed with peer-researchers in the EU-funded Easy Reading project. These "interventions" allow for evaluation of how well IPAR-UCD solutions work. The data analysis uses the iterative comparison cycles. These could be adapted and re-tested. During the project, academic researchers initially collaborate with the peer researchers as target group for a requirement analysis. The IPAR-UCD concept addresses peer researchers' need for support by helping software designers and developers to better understand and meet the requirements of users with cognitive disabilities through the inclusive user-centered design process. Later, peer-researchers alone or as group communicate their thoughts and experiences with the prototype. As input for a new software system, the feedback from users identifies useful features and problems. In this way, the developers receive feedback directly from the future user. Ideas and developments fit together or have to be further adapted thus ensuring accuracy in the development process. As focus-groups the research teams use methods such as brainstorming, card sorting and storytelling. As single person or as a research tandem, they use adapted user-testing or the cognitive walkthrough.

Key results: People with cognitive, respective learning disabilities are no longer objects of research but rather participate jointly in the research. This concept succeeds when research partners engage with each other, when information and materials for peer researchers are available in understandable language, when enough time for explanations and repetitions and personal communication and a common consent is found. In the future, the IPAR-UCD concept which addresses peer researchers' need for support, can help software designers and developers to better meet the requirements of users with cognitive disabilities through an inclusive user-centered design process.

Conclusion: Inclusive research challenges traditional research. This design-based intervention has shown that it is possible to involve people with cognitive disabilities in R&D as testers but also as developers and idea providers.

Keywords: e-inclusion, people with cognitive disabilities, IPAR-UCD, inclusive R&D, software engineering.

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"From Word to Sign": Developing a Reading Application for Deaf and Hard of Hearing Israeli Sign Language (ISL) Users

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Background: Reading is an integral part of our daily life. For Deaf and Hard-of-Hearing people (DHH), they often face significant difficulties in this area (Convertino, Borgna, Marschark, & Durkin, 2014; Mitchell & Karchmer, 2011) As a result, this population often has a higher number of individuals with developmental language disorders (Luckner & Handly, 2008; Miller, 2010). Crucially, an impairment in this basic skill leads to negative impacts in other aspects of life (Trezek, Wang, & Paul, 2011). Numerous studies have demonstrated that access to a sign language for DHH individuals results in improved literacy skills generally, and to reading acquisition specifically (Dammeyer, 2014; van Berkel-van Hoof, Hermans, Knoors, & Verhoeven, 2016). Research of this nature led me to develop "From Word to Sign", a reading app tailor-made to this population, designed to improve reading skills for native users of sign language. The premise for this app development is the assumption that an assistive technology using sign language may significantly improve the reading of this population.

Rational: Developing "From Word to Sign" app: People with specific reading disorder can use reading software when they are confronted by an unclear word. However, for people who are deaf, this opportunity doesn't exist (reading software is not available for them). The "From Word to Sign" app enables them to compensate of their reading disability: when they face an unclear word, they can touch the word in order to operate the extension. Then they can see a short video in the sign language of that specific word that they are required to comprehend.

Test report: The application test session included five deaf immigrants aged 30–50 (three men and two women) which immigrated to Israel four years ago from France, the Ukraine, and Sweden. They were recruited for this session study through personal acquaintance with the author as their Hebrew teacher. Two-hour meetings were established with each participant, asking them to read a Hebrew text with the possibility of "recitation" and translation of unfamiliar words using Israeli Sign Language (ISL) with the app – which presents the word, its sign, and denotation. After reading the text, I asked them to sign the text in ISL.

Preliminary findings: Two participants in the pilot successfully achieved complete reading comprehension using the app while, in contrast, three achieved partial comprehension. Moreover, a review of the data from the app revealed nine areas of difficulties faced by participants: new words, words with multiple ISL translations, multi-word terms, visually similar signs with different denotations, enunciation, high-register words seldom used in daily practice, conjugations, noun modifying verbs, and visual demonstration.

Conclusion: The app should be examined and exposed to a larger group of deaf, native-born readers without additional impairments. In addition, by setting a pilot team of teachers, who teach DHH students, we will collect a wide range of findings and conclusions, in order to optimize its development. The pilot team will be responsible for updating online reading texts and will report on the effectiveness and the difficulties in using the app.

Keywords: Reading Application, Deaf and Hard-of-Hearing people (DHH), reading disorder.

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Arches Project – Validation of Technological Outcomes of Gaming Software based on a Participative Research Methodology

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Background: This paper presents a case study of software gaming development that formed part of the Accessible Resources for Cultural Heritage EcoSystems (ARCHES) Project. ARCHES is a three-year-long European Union Horizon 2020 funded project with partners within the heritage and technology sectors in four European countries. The project ends in December 2019, and uses an innovative participatory research approach to understand and address issues relating to cultural access within museums for people with sensory and learning access needs. ARCHES has three phases: *Phase 1* involves developing new technologies; *Phase 2* involves testing and redeveloping these technologies; *Phase 3* involves checking the new technolo-

gies are ready for others to use. The aim of the project is to solve barriers to learning about cultural heritage through technological solutions built through research groups. The research groups are made up of people with a range of different access preferences, are located in four cities in Europe London, Madrid, Oviedo (Spain) and Vienna – meeting on a fortnightly basis. Participants' input is collected and fed back to the technology partners, who develop and improve their chosen technology based on this information.

Method: The project is based on participatory research, informed by a social model of disability, which argues disability is a result of the way society is organised. Data is collected through fortnightly meetings during which participants' views are collected, collated and analysed with the help of the participants themselves. Therefore, the participants are treated as co-researchers. Data collection methods include voice recordings of discussions, scribed notes created for people with hearing difficulties, photographs and data records of various alpha testing and beta testing of software, and meetings with the software developers themselves.

Key results: The proposed game was introduced to the participants in March 2017. The group was presented with a rough version that set out the different challenges they were going to face. During the testing of the game three main interrelated tensions were discovered:

1. Communication within the groups, museums and technology partners, and also between each other.
2. Previous experiences with participatory research, disability, museums, games and technology.
3. Institutional restrictions such as grant restrictions and museum marketing restrictions

These tensions were faced by all parties involved in the development: participants, museum coordinators, academic researchers and technology developers.

Conclusion: Although the project is ongoing and final conclusions are yet to be made, it appears that the participatory practice has led to improvements in software design and development. However, the tensions felt between partners indicates that the methodology needs further refinement.

Our recommendation for participant research method development is that participatory groups need to be involved in the conception of future games from the earliest possible stages, rather than being introduced to the game once it has been designed in rough.

Keywords: participatory research, software development, video games, different access needs and preferences, heritage sites.

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Participatory Methodology, Inclusive Control Systems and Inclusive Technical Capital Developed by Engineering Undergraduates and Teenagers from a Marginalised Community in Mexico

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Background: This workshop reviews an education project in Monterrey, Mexico, which was designed to teach principles of algorithms and control systems and promote inclusion and accessibility in systems design – inclusive technology is defined in this project as digital systems that provide ubiquitous accessibility, with knowledge of these systems' use referred to in this context as inclusive technical capital / inclusive capital. The educational development was part of the FabLab Campana project, which was designed to encourage community innovation in Campagna, a marginalized district in Monterrey, Mexico.

Method: The methodology used to develop the participatory teaching was Grounded Methodology (GM), an adapted form of Grounded Theory (GT), and was strongly influenced by participatory methods such as those used in the EU H2020 ARCHES Project. GM encourages the evolution of interpretive deduced theories that evolve through discourse, such as educational design, the design of technology, literature searches or observational research. Participatory methodology is an emancipatory methodology, which includes all participants in the development, design and evaluation of their own inclusive practice, training and the educational process. Although this was restricted by the short time line and prescribed project proposal, the nature of participatory practice influenced the relationship with participants from Campana, whose voices were heard in the learning design. Phase 1 was teaching Tecnológico students and Campagna school students about the nature of inclusive technology and inclusive technical capital, and the use of accessible features and apps on iOS and Android. Phase 2 was

the development of discrete sessions and teaching of inclusive control systems workshops by Tecnológico students, which were influenced by discussions with teenagers from Campana. Although the design of the eventual courses was implemented by Tecnológico students, the development process importantly included the opinions of the Campana school students as part of the participatory process. Phase 3 was the delivery of the workshops to school children in Campana. Data was collected through observations of the school children, logging conversations and results recorded in writing and passed on manually and on social media from verbal feedback and recorded video and e-notes.
Key results: Phase 1: During the initial workshops, awareness was raised about what disability was and how it could be found in local households, especially the sensory impairment of elderly relatives. Some students discussed the disabilities of family members, and students also raised the issue of other forms of inclusion, including multi-culturalism and socio-economic development. Phase 2: The participants from Tecnológico and Campana designed ambitious robotic projects, but had to make their devices simpler to teach the concepts of accessible STEM and inclusion. Eventually, they developed colourful items with large pieces that could be communicated through different modes. With feedback from the Campana children, teaching sessions also included elements of geometry, sensory access needs, low-cost features to make the devices socially accessible, games and multi-culturalism. Phase 3: After teaching the workshops, the Tecnológico students discovered that logical games and participatory practice were particularly useful for teaching aspects of inclusion, and found active objects such as robots engaged children's attention and enthusiasm.
Conclusion: The long-term benefits of developing inclusive technical capital with future systems designers is unknown given the time constraints of the project, however the students and school children engaged with the notion of designing inclusive technologies, and related inclusion and control systems design. In addition, through discussion and participation, students also thought about other aspects of inclusion not considered in phase 1, that could further develop their own design of inclusive systems technologies.
Keywords: Control systems, education, inclusion, inclusive capital, grounded methodology
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Starting on the Innovation Path for a Fatigue Management App for People with Multiple Sclerosis

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Background: Fatigue is a common symptom of MS, affecting 75–95% of people, and is a major cause of reduced quality of life. FACETS is an evidence-based face to face course that combines energy conservation and cognitive behavioural approaches. It has a statistically significant impact on fatigue severity and fatigue self-efficacy. However, people with MS aren't always able to attend the multiple sessions, and, they also often have difficulty sustaining gains in the longer-term. The initial app conceptualisation came from research and practice evidence that identify the main components and goals of the FACETS programme. The starting aim was to simply replicate or substitute these components and goals adopting an evidenced-based and user-centred approach. The clinical goal is to make a usable app hence all users are being consulted via stakeholder groups to avoid users having to use poorly conceived technology during evaluations or trials.
Method: Three key steps were conducted in preparation for development, each with a specific intended output. Firstly, a systematic scoping review of literature grounding FACETS. Also identifying key components, adaptations, and any currently missing elements of behavior change. Secondly, ideation with MS professionals to capture explicit experiences and knowledge which supports, contrasts, and extends the FACETS literature. Technologists also contributed their knowhow to help specify the app concept. Thirdly, review the concept of the app and it's features in open discussion with stakeholders.
Key results: Examination of FACETS and the literature revealed: the core underlying theories include the cognitive behavioural model, social cognitive model, self-efficacy, and self-management theories; and, change in behaviour is facilitated by the use of energy conservation strategies, which include rest, sleep, healthy lifestyle, activity adaptation, and goal setting. The ideation phase was a very efficient way to simultaneously explore the design and content of the pro-

posed app. Maintaining FACETS as a facilitated course in an app produces a text heavy and screen heavy app. The authors concluded a different approach for an app was needed. One where the activities the users would engage in would still contribute to behavioral change for managing fatigue by drawing on the underlying accepted theoretical models. Further adaptations were suggested because for instance clinical practice suggests FACETS class members are resistant to the cognitive components and, opportunities to employ feedback are missing. The ideation also established that the app should be used with light touch service involvement and for self-management.

Exploring the app concept and designs with users – professional (14) and people with MS (8) – confirmed the desire for such an app. In addition to many aspirational features importantly it was found that professionals and people with MS did not agree on some key aspects.

Conclusion: A combined clinical, academic and commercial developer team using evidence-based components to develop app content, and then consulting with stakeholder groups is effective to start innovation. Despite work being preliminary, key app components have been identified which show potential to at least supplement the current delivery of the FACETS programme. Future evaluation of the app will be needed to establish evidence.

Keywords: Multiple Sclerosis, fatigue, app, innovation, user-centred.

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Special Thematic Session 3
Making STEM Accessible to Disabled People

Science, technology, engineering and mathematics (STEM) can be considered to be at the basis of modern society, making it essential that they are fully accessible to disabled people. However, relatively limited attention has been given to STEM accessibility compared to many other subjects and there are still significant barriers to be overcome. Particular issues include, but are not restricted to, difficulties in representing notation and formulae in an accessible format, reading images and graphs and making both virtual and real laboratories and field work accessible. Negative attitudes and misconceptions about what disabled people cannot do also act as barriers and concerns about health and safety issues are sometimes used as a pretext to exclude disabled people. There is also a need to avoid learning aims which cause difficulties for some groups of disabled people, such as being able to draw graphs on paper rather than analyse the results of graphs produced by software. This session will discuss the full range of issues associated with making STEM accessible, with a particular focus on the role of assistive technology and tools designed to support accessibility. Chairs: *Marion Hersh and Barbara Leporini*

Natural Language Processing for Non-visual Access to Diagrams

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Background: Current accessible alternatives to diagrams for blind persons pose many critical drawbacks hindering their take-up, to the point where appropriate access to diagrams has been labeled as "the last frontier in accessibility". Dialogue-based approaches to graphics, in which users communicate with the image via speech, are a novel area of research whose evaluation has yielded very promising results in overall expressivity and user satisfaction.

Method: An accessible Web application prototype implementing a natural language processing (NLP) pipeline to semantically annotated diagrams has been designed. Diagrams are first given formal semantics via supporting ontologies that may be embedded within the graphic itself by using SAI (Semantic Annotator for Inkscape), an authoring tool for semantically-enhanced graphics. The resulting ontologies may then be explored by a blind user by means of speech in a natural manner via queries in natural language on a fully accessible Web application. The presented method expands on previous publications by the authors by focusing on the specific NLP techniques employed. Some of these techniques include:

Automatic inference of analytical tasks and operands from a user's query in natural language through ontologically-motivated heuristics.

Use of automatic clarification dialogues where users are asked to interpret ambiguous or unknown elements found in their query.

Presentation of the result or lack thereof to the user.

Support for non-visual navigational tasks of graphic primitives through speech commands.

Bookmarking of graphic elements and other methods that contribute to preventing overloading the user's

working memory while using the natural language interface (NLI).

These techniques mostly stem from state-of-the art research in dialogue interfaces to ontologies that we have expanded and adapted for their use in accessibility. We also demonstrate the integration of techniques that adapt the NLI to the specific needs of blind users, as most current research on NLIs does not focus on accessibility.

Key results: This submission deals with the novel research question of how to enable dialogue-based access to diagrams, and it is the first of its kind we have been able to find in the literature. Heuristic evaluation of our methodology has shown that NLIs are a satisfactory approach to non-visual access to diagrams, their key advantage being the lack of necessary previous training of the users and that it requires no extra software or hardware besides what blind Web users are accustomed to employ for surfing the Web.

Conclusion: Our research shows how natural language interfaces are a promising novel approach to non-visual accessibility of diagrams. We hope that the proposed NLP pipeline will be exploited by other authors fostering future research in accessibility to visually displayed STEM materials.

Keywords: Non-visual diagrams, natural language, accessibility.

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Technology Support for Inclusive STEM Laboratories: State-of-the-Art and Open Challenges

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Background: This research is motivated by the importance of science, technology, engineering and mathematics (STEM), including for many careers, understanding increasingly important public debates and policy formulation on issues such as cybersecurity/privacy management and genetically modified organisms and for personal life e.g. budgeting. STEM accessibility seems to have received less attention than that of other subjects. Particular areas of difficulty/exclusion are laboratories, fieldwork and access to formulae. This presentation will focus on laboratories.

Method: There are three main components:

1. A review of the literature.
2. An examination of the authors' previous work.
3. An evaluation of the issues drawing on the authors' experience as disabled people working in STEM.

Key results: The relatively limited literature dating back to at least the 1980s recognises that disabled students require similar laboratory experiences to other students and that disabled people do not raise particular safety issues despite the use of health and safety considerations as a pretext to exclude them. Both design for all and adaptations for specific individuals and people with particular impairments are required. The former includes an uncluttered layout, wide aisles, good signage, adjustable height tables and seating and commonly used equipment close together. Demonstrators and technicians should have training in working with disabled students and staff and in supporting particular disabled students.Both the increasing capabilities of technology and the role of assistants have been noted. However, technology can support a more independent lab experience. The use of remote computer controlled labs and virtual simulations have been suggested, but should not replace physical lab accessibility. Accessibility of this software can be improved by text labels, keyboard access, personalised settings and auditory feedback, which should have an 'on/off switch'. However, challenges are still available for working remotely and effectively with certain experiments, such as to get back information on what is happening, or on the colour or reaction of particular substances. Talking lab probes were introduced in the 1980s, but not mass produced due to cost. More recently, free script files have been developed to make Vernier lab probes compatible with the JAWS and Window Eyes screenreaders to allow real time access to data by blind and dyslexic people. A handheld computer with screenreader has been developed as a portable data collector. Light microscopes have been made accessible to physically disabled users through a remote viewing web-based application. Mounting a video camera can avoid the need to use the eyepiece. A motorised microscope with an automatic load slider can be used by physically disabled and low vision users. Low-tech adaptations, including easy-grip handles, lower seating and 3D tactile models, could benefit all laboratory users.

Conclusion: Technology has considerable not fully tapped potential in improving lab accessibility. Initial work could focus on:

– Developing a wide range of equipment with speech output and screenreader compatibility.

– Developing precision robot manipulators compatible with a range of equipment which can carry out manual operations and be operated by various assistive devices.

– Using adjustable-height benches and equipment, easy-grip devices, tactile models.

Keywords: STEM, lab accessibility, accessible equipment, low tech adaptations, assistive devices.

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InftyReader Lite: Converting e-Born PDF into Various Accessible Formats

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Background: One of the most serious problems in digitized STEM (science, technology, engineering and mathematics) contents, which are usually provided in PDF, is their poor accessibility. From the viewpoint of computerized processing to convert PDF into an accessible form, PDF can be classified into two types. "E-born PDF" is produced originally from an electronic file such as a document in Microsoft Word, LaTeX, Adobe InDesign, etc. (without copy protection). We refer to all the others as "image PDFąőąŕ. The most significant advantage of e-born PDF is that the information on each character/symbol such as its character code, font type, coordinates on a page is embedded in it.

In ICCHP2016, we reported a method to recognize STEM contents in e-born PDF, in which character information extracted directly from a document was combined with analysis technologies of Mathematical OCR (optical character recognition). It was very effective; however, in the inside of mathematical formulas, a font rectangular-area extracted from e-born PDF by a PDF parser often differs significantly from the graphical area of the original character image. Thus, it cannot be used for mathematical-structure analysis as it stands. To correct that, we still had to use OCR engines in our STEM-OCR software, "InftyReader".

Method: We have recently adopted a new powerful PDF parser that also provides us with "vector-image information" for printing characters/symbols. Using it, we can get the true graphical area of the original character image even in the inside of mathematical formulas. It allows us to develop new software, "InftyReader Lite (IRL)" that does not need any commercial OCR engines for recognizing STEM contents in e-born PDF. Since its recognition process no longer depends on image OCR, accurate conversion into text and mathematical-structure analysis can been done even if characters/symbols have color ornaments or a background image.

Key results: IRL can recognize just e-born PDF; however, IRL can convert it into various accessible formats as same as the standard version of InftyReader. That is, a recognition result can be exported in IML (the original xml in Infty software), LaTeX source, XHTML with MathML, MS Word, Multimedia DAISY ("Digital Accessible Information System": an international standard format for accessible e-books), accessible EPUB3, "ChattyBookąőąŕ, "PDF with TeX", etc. Here, ChattyBook is audio-embedded HTML5 with JavaScript which can be read with a popular browser on various platforms (Internet Explorer, Chrome, Fire Fox, Safari). ChattyBook has the almost-same functionality and operability as DAISY. In Japan, many multimedia-DAISY textbooks are now converted into ChattyBooks, and thousands of print-disabled students (mostly ones with developmental reading disorder) use them. PDF with TeX is a new-type of accessible PDF, in which text information is embedded, in actual reading order, in the background of the original-PDF page image. Mathematical parts are represented in LaTeX, and it is totally accessible for print-disabled people to read STEM contents with a screen reader.

Conclusion: IRL should be a good/low-cost solution for print-disabled people to convert (inaccessible) STEM contents in e-born PDF automatically/easily into various accessible formats.

Keywords: e-born PDF, accessibility, conversion, DAISY, STEM

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An Investigation into Pedagogical and Opportunity Barriers in STEM Education of Visually-Impaired Nigerians: Why Disabled People Must be Involved

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Background: Access to labs and field work are further barriers to STEM. Health and safety considerations are often unjustly used to exclude disabled people from practical work. in Nigeria, a West-African country, the exclusion transcends industrial-hazards as visually impaired individuals are denied access to STEM education and by extension laboratory and field-oriented professions. While unavailability of standardised notations, inappropriate resources, unsuitable teaching strategies, and lack of visually impaired STEM professionals who could serve as role-models have been found as barriers to STEM career of visually impaired persons, nonetheless, the exclusion remains unabated. It is against this background that the pedagogical and opportunity barriers in STEM education of visually impaired learners were investigated. To achieve the objectives of the study, the following research questions were raised: What are the barriers to STEM education of visually impaired learners? What opportunities do visually impaired learners miss as a result of these barriers? And How can these barriers be eliminated?

Method: Informed by the popular disability mantra "Nothing about us without us", the researcher sought a true and general representation of actual experiences of visually impaired persons. Ethical approval was obtained from executives of Light for the Blind People, Nigeria who helped in seeking their members' consents to participate in the research. Descriptive survey design was adopted. Study population was made up of visually impaired students from 36 states of Nigeria and the Federal Capital Territory. Using nonprobability or non-random sampling technique, a total of 401 participants who attended the annual meeting of the association was conveniently and purposively selected for the research. Out of the 401 copies of the closed-ended structured questionnaire that were administered, only 380 were found usable. Data collection and analysis were conducted within three weeks. Four-type Likert scale was used, and mean scores were calculated for data analysis.

Key Results: The study revealed that: visually impaired students face barriers to STEM education due to stereotypes revolving around their capabilities (2.93); barriers to STEM subjects limited their educational and career opportunities (2.52); well-defined notations can eliminate these barriers (3.14).

Conclusion: Although, these results are specific to Nigeria, in general, disabled people are misconceived and excluded from practical-oriented education and professions in both developed and developing countries. It is therefore concluded that a lot of work is re-quired to change social negative attitudes towards visually impaired persons as provision of standardised notations can only help in reducing the barriers. Recommendation was then made that further work is needed to remove the barriers that prevent disabled people from accessing laboratory and field works.

Key words: Pedagogy, Barriers, STEM, Visually-Impaired-Persons, Nigeria.

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Robot-supported Inclusion and Learning: A Case Study on the KUBO Robot in Early Childhood Education

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Background: The presence of educational robots in preschool and early primary school settings is getting stronger and has shown to have powerful playful qualities and to support learning. Research within socially assistive robotics in education suggests embodied robotic technology may facilitate social engagement and support inclusion, however little research has been conducted on whether the act of programming social robots may play an important part in discovering and designing for diversity in play and learning. This paper presents findings from a case study on the educational robot KUBO in Denmark and proposes a participatory and practice-based approach to the design of robot-supported learning aimed at the transition between preschool and primary school. The purpose is to support and empower children's essential life skills including imagination, collaboration and communication skills and to provide pathways capable of detecting and including a diversity of children's needs and skills in a more advanced way than currently offered by traditional educational technology.

Method used: Kubo is a mobile robot developed by Danish startup company Kubo Robot, designed to support learning for children in early primary school in various subjects such as coding, language, and music through a tangible coding language; TagTiles. In the case study, teachers and pedagogic professionals co-developed robot-supported learning designs with KUBO and tested these in three different scenarios; math teaching in 2nd grade, play-based learning in kindergarten as well as a 'transition' experiment in

which 2nd grade students were teaching young children (age 5–6) how to code using KUBO. Data included four instances of participatory observations, interviews with the teacher and pedagogic professionals as well as in-situ interviews with children.

Key results: The case study provides valuable insights into inclusive practices applied when implementing robot-supported learning designs (e.g. using a storytelling approach to facilitate computational thinking and understanding of coding concepts or applying peer-to-peer learning to empower children with learning disabilities), however, new potential inclusive practices also emerged from experimenting with the robots. For instance, a child's individual experimentation with programming in ways very different from his peers (e.g. applying engineering methods) turned out to reveal different skills but also needs, which may support more diverse approaches not only to the technology, but to learning in general.

Conclusion: Findings from the case study indicate that the application of robot-supported learning designs may support the visibility of children's diverse needs, skills and interests and facilitate the emergence of new inclusive practices. However, further research is needed to develop systematic approaches to inclusive robot-supported learning designs and to quantify its effects in practice, particularly in transitions between preschool and primary school.

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Automatic Support for Web Accessibility Evaluation

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Background: Designing for people with disabilities is becoming an increasingly important topic for several reasons. Accessibility has become necessary due to the rapid growth of online information and interactive services provided by web and mobile applications. The recent European Web Accessibility Directive (WAD) promotes the rights of disabled people and requires consistent monitoring of accessibility in public websites.

Even if the accessibility validation process cannot be fully automated, in order to support accessibility, it becomes important to have validators able to check, automatically or semi-automatically, the correspondence between the requirements of accessibility guidelines and the characteristics of the Web pages under consideration. These tools are useful for those involved in developing websites, as through them designers and developers can easily and quickly check whether their work meets the considered accessibility requirements.

Method: We have carried out an analysis of the state of art in the area of accessibility validation tools and elicited feedback of stakeholders working in public organizations with online surveys and interviews. We thus found some common issues. Expandability and upgradeability: newer technical guidelines get released, and while there is one international standard (WCAG), some countries make modifications to it. For the developers of validators, extending the set of guidelines supported by their tools can be a major undertaking. Alignment with the latest technology: in the ever changing panorama of technologies, the first generation of validators often appears to be unable to effectively validate websites made with the most modern technologies. Limited effectiveness of the reports: people with different roles (developers, designers, public officers) need reports containing different information for improving the site.

Key results: We have designed and implemented a new version of the MAUVE validator, available at https://mauve.isti.cnr.it/, aiming to address the issues identified. Guidelines are specified through an XML-based language, and externally stored, so that they can be easily updated to include new guidelines. Therefore, we have specified the new success criteria introduced with the WCAG 2.1 guidelines by using such language, so that the tool can support the validation against the latest standard. It has the ability to validate various device-specific versions of a website, and dynamic websites validation through browsers' plugins. It can provide the validation report in the EARL W3C standard format, ensuring consistent interpretation of results. It also provides developers-oriented report system, with indications of the accessibility problems directly into web page source code. The public version of the tool supports validation of web pages provided by URI or local files or direct HTML input. We have also an internal version able to support the validation of entire websites and providing a more graphical report, oriented to non-technical users.

MAUVE will also be integrated in a large-scale accessibility assessment infrastructure (under development in the EU WADcher project), which includes advanced decision support tools, and a web accessibility observatory.

Conclusion: Validators are fundamental in making the validation process more efficient, consistent, reliable

and cost-effective. We present an accessibility tool for the main stakeholders (web commissioners, web developers, ...) and discuss its potentialities.

Keywords: accessibility, automatic accessibility evaluation, WCAG 2.1, guideline specification.

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Special Thematic Session 4
Appropriate Wheelchairs, a Global Challenge – Reflect, Review, Strategize/Revolutionize

Appropriate wheelchair and seating assistive technology is often essential for people with mobility impairments' health and wellbeing. While some progress has been made, evidence suggests that despite the World Health Organization's Guidelines on wheelchair provision, training packages and other resources, getting 'the right wheelchair' remains a global challenge with provision being focused around just delivering the product instead of following an evidence-based service process. In addition, many governments have not committed to national wheelchair provision policies. Several authorities employ ad hoc, unsustainable systems instead of providing accessible person-centered services, skilled personnel, quality products, maintenance, follow up and management. Sustainable wheelchair service provision infrastructure is required from a human rights perspective.

In January 2018, USAID, World Learning and the International Society of Wheelchair Professionals (ISWP) facilitated a wheelchair stakeholders meeting hosted in Bangalore, by Mobility India. Bringing together fifty six sector leaders to share perspectives and consider future developments, the goal was to establish key priorities for the next five years to strengthen wheelchair services through policies, trained personnel and a range of appropriate wheelchairs. To achieve this goal, ten priority actions were identified to effect change towards sustainable development.

This session discusses global challenges faced and actions needed from multiple viewpoints. The importance of appropriate wheelchair provision will be illuminated by real world accounts. Collectively reflecting on ten years of development in research, education, and service delivery, the panel will review the current situation, progress made and discuss ways to build awareness towards action which will revolutionize wheelchair provision globally.

Chair: *Rosemary Gowran*

Wheelchair Stakeholders Meeting 2018 – Developing a Global Wheelchair Sector Report with Priority Actions Toward Sustainable Wheelchair Provision: Appropriate Wheelchairs, a Global Challenge

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Background: Since 2002, USAID has invested in the wheelchair sector with the goal of improving mobility and opportunities for people with mobility impairments in low and middle income countries. Investments have evolved over the years, from specific organizational earmarks to country-based and global investments in resources, policy promotion, procurement and standards. In 2006 USAID along with WHO and ISPO held the Wheelchair Consensus Conference to identify best practices for improving access to wheelchairs. As a result WHO published the Guidelines on Providing Wheelchairs in 2008 which highlights Design and Production, Service Delivery, Training and Policy and Planning as fundamental elements of the ecosystem. As a result of the Guidelines USAID made several global investments. In 2012 USAID along with World Learning (WL) and Management Sciences and Health (MSH) convened stakeholders to reflect on past learnings and identify sector priorities which were:

– Create a global initiative for greater collaboration and coordination to lead awareness raising, knowledge sharing, data collection and research, and ensure appropriate wheelchair service provision;
– Engage governments and other partners to support access for appropriate wheelchair service provision and get wheelchairs and other mobility devices on essential medical device lists and framework for Universal Health Coverage;

– Develop mechanisms to maintain quality standards for products, services, providers, and training in wheelchair service provision.

Acting upon the recommendations, USAID made several investments, including support for the development of the International Society of Wheelchair Professionals (ISWP); the Global Cooperation on Assistive Technologies (GATE) initiative; and the Consolidating Logistics for Assistive Technology Supply and Provision (CLASP) activity. In 2018 USAID along with ISWP and WHO brought together stakeholders to reflect on the three key investments identified in 2012 and define key sector priorities for the next five years.

Method: The main method was hosting a facilitated meeting to develop a challenge model. The challenge model leads participants through a process to define key challenges, strategic priorities, measurable results, obstacles and root causes and priority actions for the selected challenge.

Key results: As a result of the meeting and a post meeting advisory group Wheelchair Sector report was completed including a five-year Sector Goal and Priority Actions

SECTOR GOAL

By 2023, 10 countries have new or strengthened evidence-based, adequately-resourced, integrated wheelchair services supported by policies, competent personnel, and a range of appropriate wheelchairs.

PRIORITY ACTIONS

1. BUILD AWARENESS
2. CONDUCT RESEARCH
3. ESTABLISH GLOBAL SERVICE STANDARDS
4. ESTABLISH PRODUCT STANDARDS
5. FOSTER INNOVATION
6. IMPROVE WHEELCHAIR SUPPLY
7. PROMOTE POLICY
8. STIMULATE COLLABORATION
9. SUPPORT COMPETENCY DEVELOPMENT
10. SUPPORT GOOD PRACTICE

Conclusion: Utilizing the results identified USAID along with several donors have been making investments to implement the priority actions related to improved wheelchair access and service were identified. Several of the priority actions are now in implementation and others are being more thoroughly defined through an analysis by ATscale, a Global Partnership for Assistive Technology. Under this partnership investable interventions are being defined for donors which build off the results of the stakeholder meeting. Additional interventions are being defined for hearing aids, eyeglasses and prosthetics.

Personal, Public, Political Discourse Illuminating Context Specific Experiences Enabling and Depriving Individuals as Wheelchair Users in the Republic of Ireland: Appropriate Wheelchairs a Global Challenge

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Background: Providing an appropriate wheelchair is complex and challenging due to diversity of people, places, provision processes, personnel, procurement and the existence of relevant policies. An inappropriate wheelchair can impact severely on a person's health and wellbeing. The importance of developing sustainable wheelchair services continues to be undervalued. This paper illuminates the perspectives and experiences of wheelchair users in Ireland, reflecting personal, public and political discourse since the introduction of the WHO guidelines on the provision of manual wheelchairs in less resourced settings in 2008.

Method: Mixed methods were used: *National online survey* using SurveyMonkey[TM], exploring wheelchair service user's experiences and level of satisfaction with wheelchair and seating provision in the Republic of Ireland. *Individual semi-structure interviews* exploring wheelchair service user's personal perspectives. *Scoping review* exploring the public and political discourse on wheelchair provision in the Republic of Ireland from 2008–2018.

Key results: *Survey results* ($n = 273$) show high weightings of satisfaction across the service delivery process, yet 38% of respondents ($n = 105$, 38.5%) did not feel their wheelchair meet their needs. Results indicate ad hoc waiting times and funding streams, with a lack of uniformity at each stage of the process. Over 30% of respondents reported receiving little or no ed-

ucation and training skills. Follow up within the first six months of receiving their wheelchair product was limited (21% $n = 48$, of respondents $n = 228$); with only 41% ($n = 95$) needing wheelchair repairs satisfied with this service. *Individual interviews* ($n = 18$) reflect similar disparity. The importance and embodied nature of the wheelchair was clear, with poorly prescribed wheelchairs affecting a person's life, their physical (pressure injuries), mental (vulnerability and underlying fear) and social (engaging in the community) health. The experience of service delivery was influenced both positively and negatively by a person's relationship with personnel, including occupational therapists and sales/ vendor representatives, disputing the client centered nature of interactions and outcomes. The provision system was hard to navigate with a continuous fight to get the right wheelchair and follow up services to support this.

The *Scoping review* indicates a challenged wheelchair service within the public and political domain, highlighted in scientific published ($n = 3$), unpublished ($n = 2$) papers, questions to Minister of Health ($n = 22$) and newspaper articles ($n = 21$). Four themes emerged: *personal* lived experience of wheelchair users and their families, with stories relating to children predominant; *political* discourse reporting constraints within the system and a call for national policy; *provision* system processes were poor, with wait times having an overwhelming effect on individuals; and *place* highlights inconstancies across the country, with Dublin, Cork and Limerick reported on most frequently.

Conclusion: The significance of a wheelchair in person's life cannot be denied, yet there is a lack of clear transparent pathways, protocols and policy for wheelchair service provision to meet individual needs. Disparity exists throughout the wheelchair provision process, with many clients left waiting or fighting for their wheelchair. This work strengthens the call for a national review of wheelchair services in Ireland, with government commitment towards sustainable development as a matter of urgency.

Keywords: Appropriate Wheelchair, Service Delivery, Experiences, (Irish Context), (Disparity).

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Global Wheelchair Service Provision Capacity Building: An Online Mentoring Feasibility Study

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Background: Evidence highlights that a major factor associated with inappropriate wheelchair distribution is the global shortage of wheelchair service provision education and training. The World Health Organization Guidelines on the provision of manual wheelchairs in less-resourced settings (WHO Guidelines) recommend integrating wheelchair service provision content into existing rehabilitation programs at academic institutions… However, a 2017 study reported limited training time allocated to wheelchair service provision in some professional rehabilitation programs in low-middle- and high-income countries. To help assess the global training need, the International Society of Wheelchair Professionals (ISWP) developed and validated a Wheelchair Service Provision Basic Test (Basic Test) which aligns with the WHO Guidelines' eight (8) wheelchair service provision steps. Currently, in the majority of regions where the test has been applied, less than half of test takers pass the test with 41% passing in Africa, 44% in Asia, 46% in Latin America, 47% in Europe, 48% in Australia and Oceania, and 55% in North America, which confirms the overwhelming need to promote training and continued professional development and mentorship of wheelchair service providers worldwide. Novel flexible capacity building activities are needed to help address this need. Thus, this study addressed the following research question: *Is it feasible to implement an online mentoring program for wheelchair service providers globally?*

Method used: Fourteen intermediate wheelchair service providers enrolled in a feasibility study of an 8-week online Intermediate Level Mentoring Intervention, led by 3 experienced mentors. The program consisted of 9 tutor sessions led by mentors focusing on topics relevant to intermediate level wheelchair service provision, 5 case study sessions (mentees presented real service provision case studies and received feedback from mentors), and 3 individual meetings with mentors to clarify concepts and provide individual coaching. A goal attainment plan was created for each mentee by the mentor-mentee pair. All interactions were hosted in the Adobe Connect platform. Pre-post self-efficacy measures in intermediate level seating were taken by all mentees as well as a program satisfaction survey and focus group after participation.

Key results: The project findings indicate adequate results across all feasibility components (recruitment

(100%) and retention (50%) rates; perceived benefit (85% participant satisfaction); and adherence rate (71%). Improvements in clinical reasoning on case studies were also observed by mentors. Pre-post improvements in self-reported self-efficacy and goal attainment were noted. Satisfaction survey and focus group data showed overall satisfaction with the intervention and provided recommendations for improving future program iterations.

Conclusion: An online mentoring program for intermediate level wheelchair service provision is a feasible intervention for a subset of intermediate wheelchair service providers and may improve providers' goal attainment and self-efficacy in intermediate level wheelchair service provision. An experimentally controlled study is a recommended next step to determine how an intermediate level wheelchair service provision online mentoring program improves providers' competency.

Keywords: wheelchair service provision, mentoring, professional development, education, capacity building

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A Cross-Sectional Survey Investigating Wheelchair Skills Training in Ireland: Appropriate Wheelchairs, a Global Challenge

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Background: Wheelchair skills training is a vital aspect of wheelchair service delivery, yet they are arguably overlooked in many contexts. Training can contribute to the prevention of pressure injuries and fall-related injuries, empowering users and improving health and wellbeing. The practice of wheelchair skills training provided to wheelchair users by Irish clinicians is highly variable. This paper presents the results of a study exploring wheelchair skills training practice among Irish clinicians.

Method: A cross sectional survey was conducted using SurveyMonkey[TM]. Invitations were sent to associations and special interest groups known to employ professionals involved in wheelchair service delivery (e.g. Occupational Therapists, Physiotherapists, Rehabilitation Engineers). Questions related to wheelchair skills trainings offered to wheelchair service users, wheelchair skills components included and nature of clinician's education and training to provide training in wheelchair skills. 147 respondents opened the survey and 91 responses were received from occupational therapists and one rehabilitation engineer. Quantitative data were combined, and summary statistics were carried out, when appropriate, using SPSS Statistics (i.e. frequencies, proportions, and cross-tabulations). Qualitative responses were inputted into an Excel spreadsheet and a content analysis was carried out.

Key results: Consensus among respondents was that training is often provided to new users ($n = 91$, 89%), however, it is limited to mostly instruction in transfers and simple mobility techniques. Clinicians reported that advanced mobility skills were sometimes or never taught ($n = 81$, 72%). Clinician's confidence instructing various skills corresponded with the frequency of instruction. Clinicians reported that they would like to see standardized training programs established in self-maintenance and advanced wheelchair skills.

Conclusion: The results indicate a need to further develop wheelchair skills training delivered by occupational therapists and others. Formalized education and training to improve Irish clinicians' knowledge and confidence to provide more advanced wheelchair training is needed. More streamlined wheelchair skills programmes would teach users about safer wheelchair use, while enhancing health and wellbeing and greater occupational participation.

Keywords: Wheelchair skills, Wheelchair skills trainings, Occupational Therapy.

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Improving Global Wheelchair Product Quality

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Background: In 2008, the World Health Organization published Guidelines of the provision of Wheelchairs in Less Resourced Settings (LRS) which emphasized the need for all wheelchairs to meet standards pub-

lished by the International Standards Organization and for the standards to be adapted to the adverse conditions common in LRS. This guidance was in response to the widespread distribution of poor-quality wheelchairs in LRS that failed quickly and left the rider stranded and/or injured. In spite of the WHO's authority and influence on global practices, wheelchair quality has not improved significantly, nor has the ISO standards been adapted. The work described here was to help implement WHO's recommendations to improve overall wheelchair quality globally and eliminate the distribution of inferior quality wheelchairs.

Method: A working group of wheelchair experts familiar with ISO testing and wheelchair design for LRS was established in 2015 by the International Society of Wheelchair Professionals and was tasked with helping to implement WHO's recommendations by identifying and prioritizing the tasks associated with improving wheelchair product quality in LRS. Following this activity, the highest-priority tasks were carried out by working group members.

Key results: Working group members included individuals from universities (University of Pittsburgh, LeTourneu University, Massachusetts Institute of Technology) and non-governmental organizations and Charities (ShonaQuip, LDS Charities, Motivation Charitable Trust). Priorities identified by the group included (1) the need for a best-practices guideline on wheelchair design (2) the need for a caster durability test method, (3) the need for a rolling resistance test method, and (4) the need for a whole wheelchair testing system. All four of these priorities have been accomplished, leading to multiple publications, open-source materials to support improve wheelchair quality, increased testing capacity, and test-results which have led to improved products.

Conclusion: Through a global collaboration and coordination of the wheelchair sector, major progress has been made toward implementing WHO's recommendation. The outcome has led to tangible tools for the wheelchair sector to leverage to improve product quality, and better collaboration across global partners to help implement WHO's recommendations.

Keywords: wheelchair, product standards, less resourced county

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On Tire Pressure and Comfort of Manual Attendant-Controlled Wheelchairs

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Background: For physically impaired persons, the wheelchair is indispensable travel means. However, wheelchairs may cause motion sickness or discomfort and annoyance due to vibration when moving. In particular, the tire pressure affects when traveling over a level difference. The most commonly used English-style valve for wheelchairs can insert air into the tire but cannot adjust the air pressure. Therefore, it is unclear how the wheelchair tire pressure affects the vibration. This research evaluates the influence on vibration due to changes in tire pressure of the manual wheelchair, using a tire pressure indicator suitable to the English valve.

Method: A dummy heavy load was placed on the seat of a manual wheelchair to assist the vibration measuring device manufactured in this experiment, and a triaxial accelerometer was attached thereon. Also, an electric wheelchair was run a road surface with irregularities at constant speed and constant intervals. A tire pressure indicator manufactured for this study was attached to both sides of the rear wheel of a manual wheelchair, and a 25 kg dummy heavy load was placed on the seat section. The tire air pressure was set to 80 kPa, 160 kPa, 240 kPa, and 320 kPa. Next, a sensory evaluation of riding comfort was carried out. Evaluation items were set to 4 items, in addition to the three items of comfortable feeling, comfortable feeling and seating comfort of the buttocks, and the strength of the shaking during traveling, both at rest and running. The experiment was conducted with the cooperation of 10 subjects. The average age of the subjects was 21.9 years.

Key results: FFT analysis was performed on the acceleration data measured in the vertical direction. From the results, comparison was made between each tire pressure and the maximum power spectrum of the manual assistant wheelchair and the frequency at the maximum power spectrum were compared. Experiment results revealed that the maximum power spectrum increases as tire pressure increases. As a result

of the significant difference judgment, there was a significant difference between the maximum power spectrum and the frequency at the maximum power spectrum when the pressure of the tire air pressure was separated by 160 kPa. Although there was no difference due to the difference in air pressure between the seating comfort at rest and the security, it was found that lower tire pressure increases sitting comfort, which becomes worse at the higher air pressure. The result when traveling was that, for all items of comfort, seating comfort and the intensity of shaking, the tendency was higher as the tire pressure decreased. In particular, the three items of sitting comfort, sense of security and strength of shaking showed strong significance levels.

Conclusion: It became clear that the tire pressure and the maximum power spectrum of the wheelchair, the frequency at the maximum power spectrum, and the integral value are proportional. A significant difference was observed when the tire air pressure was 180 kPa away from the maximum power spectrum and the frequency at the maximum power spectrum. When running, the result that the ride comfort decreased as the tire air pressure increases, but in general, the driving force decreases as tire pressure increases, so there is a trade-off. In the stationary state, the lower the tire air pressure, the higher the comfort. In nursing homes and other facilities, it is suggested that air pressure is must be adjusted with someone sitting in a wheelchair for a long time.

Keywords: Wheelchair, Tire pressure, Traveling over a level difference, Vibration, sensory evaluation.

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Special Thematic Session 5
Eye gaze technology: accessibility, usability and effect on participation and communication for persons with severe disabilities

This session presents latest research findings and lessons learned from an international interventions study and a total survey involving eye gaze technology users in all ages. The speakers, researchers and clinical practitioners, are from Sweden, Dubai and USA. First findings from a total survey study in Sweden reporting on accessibility, usability and different aspects of eye gaze technology usage in everyday life will be presented. The users were in all ages, (171 users, 4–81 years) with diagnoses such as cerebral palsy, Amyotrophic lateral sclerosis (ALS), Rett syndrome, and multiple sclerosis (MS). Differences between children and adult users (diagnosis, accessibility, daily usage, and usability), and which users seem to benefit the most from eye gaze technology provision will be reported. Next, research findings and lessons learned from an international intervention study will be presented. Children with complex needs that were provided with eye gaze technology were followed over time and measured both with and without the assistive device. Active participation in activities, functional independence in everyday life and communication behavior with and without eye gaze technology as well as guidelines for clinical practice will be discussed. The session provides in-depth knowledge and outcomes of how eye gaze technology can contribute to everyday life for people with severe disabilities. The session also includes experiences in the application of eye gaze technology in clinical practice. The audience will have the opportunity to share experiences of eye gaze technology and participate in a discussion of how research findings may benefit clinical practice.

Chair: *Helena Hemmingsson*

Eye Gaze Controlled Computer: A Total Survey in Swedish Context

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Background: Eye gaze controlled computer (EGCC) is an assistive device (AT) that provides people with profound physical impairments opportunity to control a computer with eye gaze and by that communicate and participate in the digital world as well as in society. Few people have access to EGCC and existing research is scare, typically focus on a single diagnosis, either adults or children and include few persons. This research includes all EGCC users in Sweden in order to investigate which groups that receives EGCC as an AT, in what activities it is used, the effectiveness of the AT and users' perception of usability in everyday life.

Method: Design: Total survey. Assistive technology centers in Sweden identified all inhabitants with a prescribed EGCC and mailed them (if < 18 years old, the parents) a questionnaire. The questionnaire comprised 1) person characteristics 2) eye gaze technology usage (settings, activities, duration, frequency, effectiveness and efficiency) and 3) satisfaction with device and

related service. Descriptive statistics, non- parametric and parametric analyses were performed to describe the whole sample and to make comparisons between adults and children (< 18 years old).

Key results: The questionnaire was answered by 111 adults and 60 parents (child version), response rate 42%. No significant differences between respondents ($n = 171$) and non-respondents ($n = 232$) were found. The participants' ages ranged between 4 and 81 years with the majority in school or working age (mean 40 years, sd 19.7), 49% were females. Most common diagnosis was Cerebral palsy (CP) among children (76%) and ALS (26%) among adult users. The time for accessibility of EGCC ranged up to eight years with a mean time of 2.0 years (sd 1.7). For most (79%) eye gaze was the only option to control a computer and nearly all (93%) used Tobii products. Sixty-three percent had daily usage of eye gaze technology while about one third had weekly usage (33%), or less often (4%). Overall, participants are quite satisfied with the eye gaze technology as an AT.

More adults (45%) than children (18%) used EGCC 2 hour or more/day during leisure ($p < 0.01$). A few, three children (5%) and 17 adults (16%) had usage for more than eight hours per day. Most children (82%) used EGCC in school and most common up to 2 hours/day (57%). Adults, to a higher extent than children ($p < 0.01$) thought they could use the EGCC in as many activities as needed (59/31%) and as often as needed (65%/38%) ($p < 0.01$). The activity repertoire by EGCC ranged up to 12 activities (m 4.8, SD 3.0). Most common activities for adults were to write (67%) and to 'to talk' (62%), while the most common activities among children were 'play and games' (74%) followed by 'to talk' (72%). EGCC was seldom used for environmental control by children although parents rated it as very important.

Conclusion: EGCC is used in all ages and both at school/work and during leisure. Daily usage was moderate although very high for a few. Overall, adults had higher use and were more satisfied with their usage than children. The full potential of applications in particular for children can be improved.

Keywords: Digital access, Children, Adults, Eye gazing.

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Eye Gaze Technology for Children with Severe Multiple Disabilities: Parents and Professionals' Perception of Gains, Obstacles and Prerequisites

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Background: Children with severe multiple disabilities are a heterogeneous group. Their problems may entail both motor and cognitive dysfunction and they typically have difficulties within all areas of activities and depend on an adult to assist them in order to play, communicate and perform any other daily activities. In some cases, eye movement is the only body movement a child can control voluntarily. As a common AAC method for these children is eye pointing (the communication partner follows the child's direction of eye gaze in order to understand his or her intention), use of eye gaze technology is interesting. However, it is both time consuming and requires specific competence to assess and introduces eye gaze technology and to prepare functional software grids for children with complex communication needs, severe motor and cognitive disorders. There is a need for more knowledge of how and for what the children use their systems, and factors that should be considered.

The aim of this study was to explore parents' and professionals' thoughts of how a gaze-controlled computer can be beneficial to children with severe multiple disabilities. A further aim was to investigate factors affecting usability.

Method: The participants were 11 parents and professionals, each of whom had taken on the role of key person in the work with a child using eye gaze technology. The systems were provided primarily for symbol-based communication but were also used for other purposes such as play, leisure and school activities. An interview guide was designed with open questions concerning important factors facilitating use and problems encountered, and also questions concerning what the child was able to do with the technology. The interviews were recorded and transcribed. The study was analysed with Content analysis, which is described as a flexible method for analysing text data.

Key results: The analysis process resulted in three categories and twelve subcategories. The children used

eye gaze technology for a variety of activities. There were gains for the children in terms of empowerment, social interaction, learning opportunities and efficient computer use. The informants mentioned that it increased the children's ability to perform activities independently, express themselves and show competencies. Inaccessibility, liability issues and technical failure were seen as obstacles, while prerequisites included time, collaboration, stimulating content, know-how and opportunities.

Conclusion: This study suggests that eye gaze technology can provide children who have multiple disabilities with new opportunities to communicate, interact and perform activities independently, if conditions are right. The results indicate that certain prerequisites such as time spent, expert support, collaboration within the closest circle of people around the child, and stimulating content are necessary to make the technology useful and sustainable. The validity of the study might be affected of the small number of informants. We did not meet the children and a limitation is therefore lack of detailed information about the use. This is needed in further research. It is also of great importance to explore the views of the children.

Keywords: Augmentative and alternative communication, Computer access, Pediatrics, Usability.

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Child and Environmental Factors Influencing Selection of Eye Gaze Technology for Trials and Adoption for Young Children: An Interprofessional Pilot Study

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Background: Little research is available about characteristics of preschool candidates for eye gaze technology and environmental influences (parental, staff and agency) contributing to selection of eye gaze technology for trials and adoption. Our goal was to determine factors influencing selection of eye gaze or another method for computer access for preschoolers with disabilities.

Method: During 2015–17, we conducted a field study with a convenience sample of twelve children, ages 3–6, attending special preschools. All children had access to agency-funded or borrowed eye gaze technology for training; trial data of participation and accuracy were collected by speech pathologists. Children participated in trials 30–90 minutes per week. We reviewed children's medical and educational records. Thirty-two service providers and 12 parents were interviewed or surveyed about their knowledge of eye gaze technology and the children's abilities.

Key results: The children's diagnoses included cerebral palsy (10) and rare neuromuscular disorders (2). Other conditions included dysarthria (12), seizure disorders (5), hearing impairment (1), cortical visual impairment (2); nystagmus (1). All had significant postural issues. All were transported in manual wheelchairs most of the time. All had difficulty handling or could not handle objects. Using any means, four children could communicate with familiar partners; the rest were inconsistent or seldom effective with familiar partners. Teams did not use cognitive scores as indicators of potential, but all children could demonstrate preferences and look at a screen.

Parental, staff, AT Team and agency factors were as follows: All parents consented to children's trials, and half had home-based trials. In year one, only 5% of multi-disciplinary staff members reported having formal training in eye gaze technology. In year two, staff with formal training increased to 70% through agency workshops. The staff cited these supports from the AT Team to be helpful in decision making: equipment loans (96% cited), implementation strategies (75%), programming (62%), team meetings (62%), instruction (62%), funding proposals (50%). The agency funded the AT Team and devices; 90% of staff perceived agency as supportive of technology.

Teams recommended the following after each year of implementation:

Year 1 – One child: Acquire insurance-funded eye gaze technology AAC; One child: Acquire insurance-funded touch-activated AAC; Three children: Continue training; Two children: Discontinue eye gaze technology.

Year 2 – Four children: Acquire insurance-funded eye gaze technology AAC; One child: Acquire insurance-funded touch-activated AAC; Three children: Continue training.

Conclusion: Preschool candidates for eye gaze technology have complex conditions impeding occupational performance. Difficulty communicating indicates widespread need for AAC in this group; seating, portability, mounting and transportation require consideration. Difficulty with manual selection of icons

on a device suggests that eye gaze be considered as an access method, but children's skills may advance and allow touch activation eventually. Children's training may extend over a year before recommendations. Some children may reject eye gaze technology. AT Teams cannot assume staff members' knowledge; professional development can increase staff expertise. Valued AT Team support can consist of equipment, strategies, meetings, instruction and funding. Agency funding may be critical to implementation. Parent participation is necessary in decision-making.

Keywords: Eye gaze technology, Preschool, Professional Development, AT Team.

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Eye Gaze Technology's Effect on Participation and Functional Independence

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Background: To actively participate in activities are challenging for children with severe disabilities worldwide. Few assistive technology interventions have the potential to support children in performing a variety of activities in everyday life. Eye gaze controlled computer (EGCC) is today a possible intervention for service providers around the world. Previous research in Sweden showed increase in activities with EGCC after 9 months intervention. To strengthen research more children should be followed in EGCC outcomes. The aim was to investigate the impact from EGCC in daily life on active participation in activities (type, frequency and duration), functional independence, and communicative behavior among pupils with severe disabilities.

Method: A multicenter intervention study with repeated measurements including 18 children (Sweden, USA, Dubai). Results for 8 pupils attending special school will be presented (Sweden $n = 3$, age: 3–7 y; Dubai $n = 3$, age: 17–23 y; USA $n = 2$, age: 5–6 y). All had severe physical disabilities (e.g. Rett syndrome, cerebral palsy, Lesch-Nyhan disease, intellectual disabilities), dependent on assistance and without speech. Intervention consisted of EGCC in daily life (Tobii I12+, I15 or Tobii PCEye Go) and services (Swe: 5–8 occasions; Dubai, USA: every week) during 6 months by an AT team to support implementation in daily contexts. Data were collected four times; before intervention (no EGCC), at 3 and 6 months EGCC intervention, after the end of intervention (no EGCC). Active participation in daily activities were documented with diary protocols (all time points). Key persons rated the impact from technology on functional independence and communicative behavior (at 6 months intervention) using Psychosocial Impact of Assistive Devices Scale (PIADS) and Communication Matrix.

Key results: All pupils performed activities with EGCC at 3 and 6 months intervention; six pupils in school and two both in school and at home. At 6 months the activity repertoire with EGCC ranged from 1–6 activities (Swe: 1,3 or 4 activities, e.g. talk, play, skill training; Dubai: 1,5 or 6 activities, e.g. talk, skill training, story selection; USA: 2 or 4 activities, e.g. talk, play, circle time), compared to no computer activities for seven pupils before intervention and for no one after intervention. Duration ranged from 12–323 minutes per userday (Swe: 12 m, 73 m, 75ạd'm; Dubai: 60 m, 72 m, 73 m; USA: 40 m, 323 m). Activities were performed between 36–100% of days (Swe: 36%, 64%,100%; Dubai: 71%, 71%, 71%; USA: 64%, 71%). Preliminary findings indicate that activities, duration and frequencies with EGCC were similar between pupils with different diagnosis, nationalities and ages. Using EGCC, functional independence (PIADS) showed positive values for all but one child in competence (median 1.21, range $-0.08 -2.00$), adaptability (median 1.3, range 0.17–2.50) and self-esteem (median 0.8, range 0–1.88). Preliminary results indicate emerging communicative behavior for some children with EGCC compared to without EGCC which will be discussed at the session.

Conclusion: The results for the first eight pupils indicate increase in active participation and functional independence after 6 months EGCC intervention. Slow development in general among children with severe disabilities indicate improvements in daily life from EGCC use. Our future investigations will answer research questions concerning changes in communicative behavior and degree of dependence with and without technology use.

Keywords: Children with disabilities, Intervention, Assistive technology, Self-help devices.

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Facilitating Participation in Routines and Activities for Individuals with Complex Challenges by Use of Eye Gaze Intervention in a Transdisciplinary Special Education Setting

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Background: For students with profound and multiple disabilities, who are eye gaze users, it is challenging to implement their IEPs through use of customized activities and resources in all school routines. This study highlights how eye gaze intervention has been embedded in various routines and activities at Al Noor Center for Persons with Disabilities to ensure participation and learning for individuals with complex communication challenges. Two approaches that constitute the bedrock of the Center's service delivery process viz. trans-disciplinary approach to assessment/intervention and activity and routine-based intervention are described. The aim of this part of the seminar is to describe implementation of eye gaze technology in a transdisciplinary special educational setting for students with severe challenges.

Method: Five eye gaze users participated in the study from Jan 2018 to Sept 2018. Trans-disciplinary intervention, training support to teachers, teaching assistants and therapists in the use of eye gaze technology, routine – based intervention and customization of resources etc. were used to ensure implementation of eye gaze training for each eye gaze user. Student – specific eye gaze equipment was made available through the school day. Thrice weekly individualized skill-specific training in eye gaze was provided. This initiative was guided and led by the Assistive Technology Specialists.

The IEP was implemented through appropriately planned activities ensuring access to eye gaze equipment in every routine. The routines included

– Communication (apps with text/ symbols)
– Academics (e-books, PowerPoint slides)
– Literacy (customized Communicator page-sets with IEP goal-specific grids)
– Music (accessible apps, software Beamz Music, Eye-play Music)
– Leisure (watching YouTube videos of their choice, online radio page-sets, Tic Tac Toe, Makeup page-sets, HelpKidzLearn games)
– ICT (page-sets for making greeting cards, Look-ToLearn software, SenICT activities)
– Art (creative art software, online Mandala creator, digital painters, pixel drawing)
– Vocational training (designing merchandize), etc.

Assessments such as Communication Matrix, Co pass assessment, Psychosocial Impact of Assistive Devices Scale, Quebec User Evaluation of Satisfaction with Assistive Technology were used to measure the usage and benefits of eye gaze.

Key results: Eye gaze usage within Al Noor's structured service delivery setup has provided opportunities to the students to access all routines, which otherwise would not have been possible. Examples of participation of eye gaze users in activities include in a music band, designing of merchandize for sale, accessing YouTube videos for leisure etc. and in areas such as communication, ICT, art, literacy etc. Learning outcomes were attained in specific skills of duration and frequency of eye gazing. Desire to communicate and eagerness to participate were observed amongst the eye gaze users. Some students displayed fatigue to tasks requiring complex and sustained eye gaze movements. This was addressed through task – breaks to overcome fatigue.

Conclusion: Structured service delivery processes, intensive staff training, access to resources and equipment and providing appropriate opportunities within routines are some of the key factors that have influenced the outcomes of this study. This study illustrates the need for service providers to integrate assistive technology devices and services into the core service delivery process to ensure participation and learning for the intended beneficiaries.

Keywords: eye gaze, trans-disciplinary intervention, routine-based intervention.

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Combining P300-based Brain Computer Interface with an Eye-tracking System to Improve Communication Efficacy for People with Ocular Motor Impairment

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Background: Brain computer interface (BCI) systems allow people with severe motor disabilities interact with the environment representing an alternative channel to access assistive technologies for communication disorders. When eyes movement are preserved but user experiences severe motor impairment, high technology aids as eye-trackers are efficient and effective solutions. However, eye-trackers performances decrease in case of oculomotor impairments such as nystagmus, gaze paralysis. On the contrary, P300-based BCIs do not rely on eye movements but on the subject ability to attend relevant stimuli. In this work we propose a hybrid algorithm, based on both EEG data and eye-gaze position, with the aim of improving efficiency and effectivness of communication aids for people with oculomotor impairments.

Method used: The hybrid BCI is based on an iterative algorithm, originally proposed by Kalika et al. 2017 that computes the probability of each item to be target as the combination of EEG and eye gaze position *a priori* probabilities. When total probability reaches a specific threshold the algorithm provides a classification result, otherwise another iteration occurs. We assessed EEG score values using a stepwise linear discriminant analysis (SWLDA) and *a priori* EEG probability was computed by linear interpolation of scores on the distributions of target and non-target stimuli. To estimate *a priori* eye-gaze probability, we assumed equal and Gaussian distributions for each item, Gaussian mean was estimated by a least square linear regression (LSLR) and covariance as the maximum of the vertical and horizontal gaze coordinates variance. We introduced constraints on the classification threshold, introducing a threshold value on the EEG scores and considering a dwelling time for the eye-gaze position. We preliminary validated offline the proposed algorithm on the data recorded from 10 healthy participants. Participants were required to carry out a P300 Speller session. Scalp potentials were collected at 256 Hz with 16 EEG active channels. Eye-gaze positions were recorded using a Tobii 4C eyetracker. The P3-speller interface (5×6 matrix of alphabetic items randomly flashing) was provided by BCI2000. We collected 8 runs of 5 characters each. In order to assess algorithm efficacy we computed the written symbol rate (WSR-REF) and exploited different variance values for eye-gaze data.

Key results: Because of low values of eye-gaze variance (0.001) no statistical differences were identified in terms of WSR for the hybrid algorithm with respect to the solely eye-tracker ($t = -0.19$, $p = 0.84$). If eye-gaze variance increases (0.1) the hybrid algorithm showed higher WSR values with respect to both eye-tracker ($t = 6.57$, $p < 0.001$) and EEG ($t = 3.72$, $p < 0.01$). This confirms that with eye movements impairments, the combination of eye-tracker data and EEG data allows for better performance.

Conclusion: Hybrid control could represent a solution to increase communication efficacy for people with ocular motor impairments who experience a decrease in performance with eye-trackers. As expected, with healthy subjects the classification algorithm is mainly driven by eye-gaze data, but offline simulations showed that EEG data improves classification performance when the reliability of eye-gaze data decreases. We will evaluate the algorithm with potential end users to further verify our hypothesis.

Keywords: Brain Computer Interface, Eye-tracker, assistive technology.

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Special Thematic Session 6
Employing MOOCs and OERs in Teaching Digital Accessibility

In 2016, the European MOOC Accessibility Partnership (MOOCAP) launched the first European MOOC on digital accessibility, on the FutureLearn platform. Since then, other MOOCs on specific subtopics of digital accessibility have been released, by MOOCAP partners and by other parties. In Europe, there is an urgent need for education and training of students and professionals studying and working in areas involving digital media. MOOCs and Open Educational Resources (OERs), optionally integrated with presence time ("blended learning"), are deemed to be an appropriate means to satisfy this need. Initially started by MOOCAP, there is a growing European community with a joint interest in harnessing MOOCs and OERs in teaching digital accessibility for a wide audience, including students at universities and professionals at work. It is imperative to join forces, learn from each other's experiences and share best practices and OERs, since the field of digital accessibility is so wide, and experts are scarce and geographically distributed. The BEYOND-MOOCAP network will host this Spe-

cial Thematic Session to facilitate an exchange of best practices and a platform for sharing OERs to reuse and for translation into local languages. All interested persons and parties are welcome to join us and contribute to this session.
Chair: *Gottfried Zimmermann*

Designing a MOOC for "Training the Trainers"

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Background: EU Directive 2016/2102, voted in October 2016, requires that new public sector websites in the EU need to conform European standard EN 301 549 by 23 September 2019. Other public sector websites and public sector apps will eventually also need to comply. The European Accessibility Act, approved by the European Parliament on 13 March 2019, will greatly expand the range of products and services that need to be accessible, including computers, e-commerce websites and mobile apps. This creates a greater need for training resources and courses for content authors and developers, among others. The MOOCAP project (2014–2017), co-ordinated by Stuttgart Media University, created 10 online courses, including four MOOCs, on digital accessibility. The resources from these courses met WCAG 2.0 level AA and were all made available as open educational resources under the terms of the Creative Commons (CC-BY 4.0) licence.
Method: The above-mentioned courses and resources are in English and many EU member states will need training resources and courses in other languages. Informal discussions with representatives of German municipalities have taught us that a course on digital accessibility should use materials in German. In Germany, Stuttgart Media University is creating a MOOC in German that is aimed at civil servants who will be in charge of leading accessibility projects and/or training developers and content authors who will be involved in making websites and apps compliant with European accessibility regulations. The target audience also includes designers and developers of digital systems in general. The course content will meet WCAG 2.1 level AA. The course will combine three face-to-face meetings, and online course modules that are spread over four months. Each online module will contain required reading and practical tasks that will

be discussed in regular online meetings (typically on a weekly basis). The course will cover accessibility basics, laws and regulations, multimedia, web accessibility (WCAG 2.1), office documents (Word, PowerPoint and PDF) and inclusive design processes.
Key results: The course contents is being developed; the course itself is scheduled to start in October 2019.
Conclusion: Since the course has not started yet, no conclusions can be drawn at this time.
Keywords: accessibility, training, resources.
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Using MOOCAP Open Educational Resources to support Universal Design and Accessibility initiatives in Computer Science programmes in Ireland's first Technological University

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Background: The recently completed Massive Open Online Course for Accessibility Partnership project (MOOCAP), funded by the ERASMUS+ Key Action 2 (KA2) grant program of the European Union, had the twin aims of establishing a strategic partnership around the promotion of Universal Design and Accessibility for ICT professionals and of developing a suite of Open Educational Resources(OERS) in this domain. This study considers how the MOOCAP OERS were used in two different situations in undergraduate computer science programmes in the Technological University of Dublin which both have digital accessibility as a common learning goal. This reflects the reported need to promote accessibility considerations amongst ICT professionals.
Method: This research involves two case studies with analysis using the Johns model of reflection. Some surveys have also provided reflective feedback. The first case study examines the role of OERs to modernize accessibility topics in a Universal Design and Assistive ICT module and the second looks at how the OERS are a valuable resource in developing a training program in the preparatory stage of a team project module. The team project uses an Agile Co-Design model with partners with Intellectual Disability. Fifteen students took part in the first case study. Twenty four students took part in the second case study. The results of these case studies will be considered in comparison to already reported international use of the MOOCAP content.

Key results: Prior to engaging with these modules, there was little knowledge of accessibility among the students. Both modules increased awareness of the role of the user in computer science. The Co-Design process was especially significant in this regard with student participants reflecting that it had changed their perception of development. Requirements were typically given to them in previous assignments. Now they have to find out what the users wanted. The OERS were an interesting and helpful resource in meeting the learning outcomes of the module. The team projects needed strong preparation and the OERS helped in achieving this. Feedback was also given that more examples of best accessible applications should augment the OERs used.

Conclusion: It is essential to promote accessibility knowledge amongst the ICT developers of tomorrow. The role of the user in application development is central to this. The MOOCAP OERS are a valuable resource in this regard. They can help achieve these outcomes in many different ways. A repository of best accessible applications would be a useful addition.

Keywords: Open educational Resources, MOOCs, Digital Accessibility, ICT Professionals.

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Harnessing MOOCs and OERs in teaching digital accessibility – experiences with a flipped classroom approach

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Background: The past few years have seen a pressing need for students and professionals in information technology (IT) to learn digital accessibility. As a consequence, an increasing number of universities have started to include digital accessibility in their IT curricula, alongside some open educational resources (OERs) and Massive Open Online Courses (MOOCs). Researches have also been carried out on pedagogies and methods in teaching digital accessibility. A flipped classroom is a pedagogical approach that promotes learner-centered instruction and replaces the traditional transmissive lecture with active in-class tasks and pre-/post-class work. In this paper we share our experiences on teaching digital accessibility using the flipped classroom approach and OERs and MOOCs created in the EU erasmus+ funded "MOOCs for Accessibility Partnership (MOOCAP)" project.

Method: The study was carried out in 3 runs of the same course from 2016 and 2018. Each run lasted for 6 weeks where the first 5 weeks were dedicated to course content and the last week were used for course summary and exam. The 5-week's content was correspondent to the 5 weeks in the introductory MOOC for digital accessibility created in the MOOCAP project. In the flipped classroom approach, we have used the OERs (in 2016) and the introductory MOOC (in 2017 and 2018 ran in parallel with the course) as the pre-/post-class work. To prepare for the classroom activities students were asked to read the text and watch the videos in the OERs and the MOOC. For classroom activities, we focused on collaborative knowledge building where students were first asked to share with each other what they have learned from the reading, and then discuss important issues related to digital accessibility. For example, what criteria can one use to select users in a user testing of web accessibility? What are the challenges in developing an accessible web form? What are the accessibility barriers can an ATM have on diverse user groups? In total, 70 students participated in the 3 runs of the course. At the end of each run an online questionnaire was distributed to gather feedback. In the questionnaire there were also fields where students could write their opinions in free text.

Key results: The feedbacks from students were in general positive. Most of the participants reported that they have enjoyed the flipped classroom approach and learning materials in OERs and the MOOC. They also thought that the materials were very useful. However, a few students reported that the approach did not fit well with their preferred learning method. They preferred to be taught rather than self-study. When some students did not prepare before class, it was difficult to organize classroom activities.

Conclusion: Our experience shows that using a flipped classroom approach to harness OERs and MOOCs in teaching digital accessibility is a promising approach. However, it is also important to take into consideration the diverse preferences and abilities of students. Further research could replicate the study, gather more evidence and provide recommendations in using OERs and MOOCs in flipped classroom for teaching digital accessibility.

Keywords: digital accessibility, MOOC, OER, flipped classroom, education.

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Exploring the impact of the Digital Accessibility MOOC

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Background: Since 2016, the Erasmus+ European project "MOOCs for Accessibility Partnership" (MOOCAP) has hosted their introductory five-week digital accessibility massive open online course (MOOC) four times. The eight partner universities provided multimedia resources and links to a wide range of topics about assistive technologies and accessible design in ICT. The MOOC aimed to help participating learners understand how those with sensory, physical and cognitive impairments may be disabled by barriers encountered when using digital technologies. By using the FutureLearn platform there were plenty of chances to discuss content, make comments as well as reflect on what had been learnt. These interactions provided the partnership with a greater understanding about the impact the MOOC had on some learners and this paper aims to explore six case studies that illustrate particular outcomes in the workplace.

Method: By examining the data collected from the FutureLearn statistics for the four Digital Accessibility MOOCs from October 2016–2018 it was found that 11186 learners signed up. 6670 engaged with the courses in one way or another and 1127 completed the courses with 1667 interacting by posting comments about the subjects discussed. On average learners commented around 13 times over the course of each MOOC. This amount of interaction was shown to be above the normal range for this type of online learning. The authors asked certain participants, who had a documented web presence, if they could explore their interactions further. The resulting six case studies were also chosen from participants with very different areas of expertise and how they shared their experiences during their interactions online.

Key results: As the case studies were collated, it became clear that the participants were not only active learners but also engaged with the majority of the content, links and formative assessments. They appeared to have a high number of comments that were 'liked' by other participants, and discussed topics with the tutors or mentors. Most interestingly when analyzing their reflective comments at the end of the first week, it appeared all six had professed that they intended to take what they were learning into their workplace.

Conclusion: The learners came from across the world and were based in research and educational institutes, designing user experiences for the elderly or tutoring dyslexic adults, working as a digital learning consultant or leading on accessibility in large well-known companies. Despite the different employment settings, all acknowledged that the course had provided them with the confidence to expand on their work in this area. Moreover, they said it had allowed them to provide support to others on the subject of digital accessibility and in most cases, this was evident in their web presence after the MOOCs took place.

Keywords: Digital Accessibility, MOOCs, Disability, Case Studies, Learners.

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Special Thematic Session 7
AI and Inclusion – Exploring the issues as well as the successes

Artificial Intelligence and Inclusion' is a subject that has been debated in terms of ethics and a lack of big data for machine learning when thinking about inclusive design for those with disabilities. The challenges are to overcome these difficulties and to develop technologies to remove the many different barriers to access. Those working in the world of assistive technologies, and digital accessibility are innovating and exploring this field in participation with those who have disabilities. This special theme aims to explore some of the innovations that are appearing and to discuss the issues that have been arising as well as the successes.
Chair: *E.A. Draffan*

AI and Inclusion: A Roadmap for Research and Development

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Background: Artificial Intelligence (AI) was a term coined in the 1950s based on the work of Alan Turing and other machine-learning experts. The term tends to cover the use of data collections, algorithms and models that can augment or assist humans in their decisions and tasks, but there is a deepening awareness that not all data collections are inclusive or algorithms transparent. Ethical issues arise where this occurs and inclusion depends a lack of bias and fairness within the sys-

tems. This abstract presents a roadmap for digital accessibility research and development using AI to support those with disabilities with examples where strategies can help prevent barriers to inclusion.

Method: A gap analysis has been undertaken to investigate where issues might be arising for those who are recognized as having 'protected' characteristics', focusing on those with disabilities. The process included reviews of EU, government, academic and commercial reports, papers. The review used five AI driven search engines, combining the terms artificial intelligence, inclusion, accessibility and disability. An online repository of the findings was developed and as the gaps appeared more in depth investigations undertaken, meeting experts in the subject to evaluate how examples of innovative developments in particular areas, could remove barriers to enhance digital accessibility and inclusion.

Key results: Around 1,782 academic papers were found using the aforementioned terms. Much has already been written about the ethical issues arising from bias and the exclusion of data relating to vulnerable groups within society so papers with 'ethics' in the title were left out of the review. At the time, only 50 papers were considered appropriate with government and disability organization reports tending to highlight the issues arising, rather than offering solutions. The reports 'that included 'disability' appeared to consider it as a homogeneous concept that could lead one to believe that one solution would fit all if it was provided. AI and inclusion appeared to be poorly defined, when thinking about disability, with many papers considering medical issues and not accessibility or design for all. Authors described using AI to support assessment, diagnosis and support for diseases and health conditions, smart living, homes and cities. Some were about assistive apps to support specific disabilities, but rarely about equity of access. It still seems that those with disabilities are expected to use additional AT without a guarantee of accessibility to the digital and built environment.

Conclusion: Successful inclusion of all vulnerable groups within the AI research and development arena remains patchy, in particular when considering strategies for access to aid those benefiting from a wide range of technologies. However, when exploring both policy and machine learning applications catering for the heterogeneity in disability (where barriers are removed), there are a variety of strategies that enhance digital accessibility. These may include personalization, localization, risk assessments, anomaly detection, and prediction or recommendation systems. Outcomes can be biased against particular needs, but if there is an awareness of these issues and algorithms are designed to cater for inclusion, enhanced digital accessibility can be achieved.

Keywords: Artificial Intelligence, Inclusion, Accessibility, Disability, Design for all.

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The four idols of AI for health and wellbeing

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Background: In the last decade or so, increased computer processing and storage capabilities, along with the availability of big data sets, have stimulated the development of more elaborate inductive machine learning algorithms and architectures. These have delivered impressive results in tasks such as natural language processing and image recognition, so much so that in contemporary usage AI has become practically synonymous with inductive machine learning and, more specifically, with deep learning.

Moreover, these results have, quite naturally, raised expectations that, with just the right amount of effort, these results will be repeated across a range of domains, automating all sorts of mundane (and not so mundane) tasks. The expectations – and accompanying hype – are such that AI now consistently appears in policy documents as a key driver of innovative services and products, of productivity gains, and of wealth and job creation across all sectors of developed economies. The health and social care sector, with its escalating needs and straitened budgets, seems particularly susceptible to the claims of proponents of this new AI. However, the degree of faith placed in AI to deliver the imagined gains is not yet borne out by evidence. There are a number of reasons to believe that the gains, while by no means negligible, will be more limited and will be more difficult and take longer to achieve and disseminate into everyday care practice and assistive technology.

Method: This discussion paper draws on the authors' experience of working with and around AI and health and wellbeing applications. Its theoretical inspiration is drawn from the work of the British philosopher Francis Bacon, one of the progenitors of modern inductive method, who in his *Novum Organum* (1620) identified

four 'idols of the mind', that is, types of common fallacies or biases that divert reasoning from the acquisition of 'true' inductive knowledge.

Key results: We propose "the four idols of AI for health and wellbeing", which apply equally to assistive technology; these are:

– *The idols of the tribe*, or fallacies that emerge from the conviction that there is, of necessity, 'true' knowledge inherent in data;
– *The idols of the cave*, or mistakes that derive from our ignorance, wilful or otherwise, of the limitations of the methods and means at our disposal;
– *The idols of the marketplace*, or the constraints which human commerce places on our endeavours;
– *The idols of the theatre*, or the failings that arise from incorrect, ill-considered or improper use of AI.

As we show, consideration of these idols allows the adoption of strategies and practices to mitigate their effects.

Conclusion: A contribution is made to a critical appraisal of the use of inductive machine learning, particularly deep learning, in care contexts. When considering the application of machine learning for assistive technology an awareness of the pitfalls should help to allocate scant resources to those tasks most likely to benefit end users.

Keywords: Artificial Intelligence, data, machine learning.

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AI Bias in Gender Recognition of Face Images: Study on the Impact of the IBM AI Fairness 360 Toolkit

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Background: Artificial Intelligence (AI) has great potentials, but also comes with risks. In particular, the "AI bias" has been described as a phenomenon that can marginalize persons with disabilities or classify as outliers. This would potentially exclude those persons from fair access to important services such as health insurance and loan programs, or at least significantly hamper them. The IBM Fairness 360 Open Source Toolkit (AIF360) addresses this problem. Its goal is to "examine, report and mitigate discrimination and bias in machine learning models". It was developed by IBM and announced in September 2018. The toolkit contains 10 algorithms to mitigate bias in AI systems. One of them is "reweighing" which is suitable for image recognition. So far, there has been little research on the impact of AIF360 regarding its ability on mitigating AI bias, and its applicability on various problem domains that are typical for the application of AI algorithms.

Method: We conducted a small study on the impact of AIF360's reweighing algorithm on the accuracy of gender recognition for face images of persons with and without Down Syndrome (DS). We used the gender recognition algorithm and a training set of 20.000 images from the UTKFace dataset which is included in the AIF360 package. These images were tagged with the gender of the person, but not with any information on DS. Also, we collected 30 images from public domain sources on which persons with DS were displayed; and 30 images from the same sources with persons without DS. The study consisted of two parts which differed in the set of training images. In part (1), we trained the system with random 16.000 images from UTKFace. In part (2), we trained the system with random 15.984 images from UTKFace plus 16 images of persons with DS (from public domain sources) – a proportion of 0,1% which is roughly the proportion of persons with DS in the German population. In both parts, we tested with images from public domain sources: 30 persons without DS and 30 persons with DS, in two modes: default algorithm and reweighing algorithm.

Key results: We found no evidence for a manifestation of the AI bias under this configuration. Gender recognition accuracy with the default algorithm was a low 70% for persons without DS and 80% for persons with DS in part (1); and 70% for persons without DS and 73,3% for persons with DS in part (2). However, when using the reweighing algorithm in part (2), there was a slight improvement from 73,3% to 83,3% accuracy. However, the sample size was too small to claim a representative assessment for this algorithm.

Conclusion: The AIF360 toolkit is a candidate instrument for the mitigation of AI bias. According to our study, the reweighing algorithm has the potential to improve the gender classification accuracy, but research with a larger sample needs to be conducted to confirm this.

Keywords: AI bias, Down syndrome, reweighing algorithm, gender recognition

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Machine Learning: Design by Exclusion or Exclusion by Design?

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Background: Many applications, from image recognition to providing credit ratings for loan applicants use Artificial Intelligence (AI) and Machine Learning (ML). They have become major technologies in everyday life. However, commentators such as the Obama White House and the World Economic Forum have noted the potential of these technologies to exclude and discriminate. This discrimination typically starts with datasets that exclude or underrepresent particular groups of people, including people with disabilities. This exclusion propagates through the Machine Learning algorithms, used in these technologies. In other words, these algorithms have developed from a design process tainted by exclusion. How does this exclusion occur in the datasets? Is it deliberate, i.e. exclusion by design or are there other reasons?

Method: This study involves a comparative analysis of four case studies from the domains of education, speech recognition, fall prediction, and credit card risk assessment. These all have important resonance for people with disabilities. Comparison is across the dimensions of:

– origin and characteristics of the dataset,
– whether exclusion is manifest or not in the dataset,
– if this exclusion is deliberate,
– what preprocessing occurs on the data set and
– implications for people with disability.

Key results: The key finding is that there is exclusion of certain groups of people in datasets used for machine learning applications. This exclusion can have serious consequences for the people who are discriminated. Education and job opportunities can be lost. A creditor may refuse a loan because the applicant is wrongly classified.

How has this exclusion happened? It may be down to ignorance. It may have been deliberate but motivated by good intentions with respect to privacy or safety or ethical concerns. It may simply be that this dataset is the only one available regardless of its flaws. However all is not lost and there may be remedial processes, especially in the pre-processing phase, which can provide some redress. Oversampling and under-sampling are of particular importance

Conclusion: It is especially important to develop inclusive datasets across many applications for underrepresented groups in machine learning. Inclusive dataset protocols and techniques, which respect ethics, privacy and safety, need to be developed. The efficacy of inclusive pre-processing techniques such as oversampling needs exploration.

Accessibility and Stigma: Designing for Users with Invisible Disabilities

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Background: While chronic pain due to overuse (e.g., Repetitive Strain Injury, some types of back pain) is often discussed in the ergonomics and accessibility literature, there are many invisible conditions such as fibromyalgia that are characterised by complex, chronic patterns of pain and fatigue. People living with those conditions often find that the number of tasks they can complete in a day is severely limited. This can be a significant barrier to fulfilling even basic needs such as self-care. At the same time, people with chronic pain are often stigmatized as "lazy", because there are often no visible signs or clear causes of their condition. Physiologically, pain affects mobility and dexterity, and un-ergonomic technology can create or exacerbate chronic pain. In this paper, we examine the extent to which these issues are acknowledged and discussed in the literature on providing healthcare or assistive technology for people who live with chronic pain.

Method: Searches covered the ACM digital library (ACM publications) and PubMed. The keyword for the ACM digital library was "chronic pain". PubMed was searched for "chronic pain" and "technology use"/"accessibility"/"usability". In addition, five key journals in the field, Technology and Disability, Journal of Enabling Technologies, Disability and Rehabilitation Technology, Assistive Technology, and the Journal of Rehabilitation and Assistive Technologies, were searched for the term "chronic pain". Chronic pain was used as the umbrella term for relevant conditions because it is a defining feature and likely to occur in the abstract, key words, or full text.

Key results: The papers retrieved are mostly concerned with eHealth solutions for chronic pain man-

agement and self-management. There is almost no consideration of ergonomic aspects. Within the health field, interventions are mostly evaluated for effectiveness and acceptability, some for usability. When accessibility issues were evaluated, the focus was on accessibility for visually impaired users, not on impairments of mobility and dexterity. There was also very little indepth consideration of the work and effort required to integrate technology into the daily life of somebody with chronic pain. A few papers highlighted that people with chronic pain were particularly affected by the digital divide.

Conclusion: Chronic pain affects mobility, dexterity, and people's ability to do the work required to use and look after their technology. These aspects are mostly neglected in the HCI, eHealth, and assistive technology literature on designing for people with chronic pain. We need to determine the relevant accessibility issues before we can begin to leverage AI meaningfully to address them.

Keywords: chronic pain, accessibility, stigma, inclusion

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AI and AAC: Linking Open Symbol Sets – A Global Approach

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Background: Artificial Intelligence depends on big data sets to provide successful outputs from algorithmic modelling. However, in the world of augmentative and alternative forms of communication (AAC), where individuals with complex communication needs may use symbols, data is scarce. This means that non-speaking symbol users have restricted choices, depending on symbol to text when communicating online with little text to symbol translation. The conversions are fraught with complications due to the different types of linguistic concepts, imagery and languages. At present, there is limited harmonization or standardization of symbol sets, so users find it hard to access suitable localized imagery to fit their present systems, unless manual modifications are made. This paper shows how symbol sets can be linked with multilingual options and how plans to use image recognition and more detailed metadata could improve outcomes

Method: The last ten years has seen studies examining the possible harmonization of different AAC symbol sets. These offered users the chance to communicate with their preferred symbols in phrases and sentences that were transcribed into text and then converted into another set of symbols from a different symbol set and into another language. The conversions used a concept coding framework with symbol sets such as Blisssymbolics and ARASAAC using European languages. This idea has been extended with the use of ConceptNet (a semantic network) and additional metadata with a wider range of languages to allow for the linking of an infinite number of symbol sets. It is proposed that the use of machine learning and image recognition could further enhance the process with a diverse range of symbols that have free to use licenses and are appropriate for AAC users across the world. This would result in ease of access to more pictographic based communication that could be personalized, localized and become increasingly culturally suitable for globalization.

Key results: So far it has been possible to automatically link five multilingual and multicultural open AAC symbol sets, providing a repository that can be searched or filtered using categories such as language, concept, label, category and parts of speech. Languages vary from Hindi to Spanish, Marathi to Arabic with the symbol sets ranging from those suitable for adults to Blissymbolics with its own grammar. All can be used with communication chart builders using an open board format (obf) for digital, online and paper based communication systems.

Conclusion: There may be challenges ahead for those wishing to explore open symbol set development to provide users with choices adaptable for personalized communication. However, a global symbols' model offers avenues into literacy and understanding of symbol to text based content. The addition of symbols for online informational content has already been considered by the Web Content Accessibility Guideline cognitive and learning disabilities task force and Easy to Read EU project teams. Nevertheless, without harmonization it will remain hard for AAC users to express their ideas, share thoughts and comprehend content across our digitally networked world.

Keywords: Artificial Intelligence, Augmentative and Alternative Communication, Symbols, Multilingual, ConceptNet.

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IoT-Based Observation Technology for Assessment of Motor and Cognitive Conditions in Children with Severe Multiple Disabilities

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Background: Medical advancement has increased the survival rates of newly born babies with multiple disabilities, which has increased the number of non-speaking children with limited responses during interactions. In order to provide good support to and interaction with them, it is urgently needed to achieve an objective means that helps to assess their motor and cognitive conditions. In this study, IoT-based observation technology was developed, which helps to record and evaluate the responses of those children while various stimuli are presented. The usefulness of the system in assessing their motor and cognitive conditions was investigated.

Method: The following two applications were developed, which support the observation of the responses of children with severe multiple disabilities. The first app, TEAK (Team Entry Assessment Kit), was designed to navigate the user, e.g., the children's parents and teachers, with the instructions of how the stimuli are presented during the observation. The app asks the user about the child's response toward the stimuli and choose a number from a five-level scale that associates with their body movement. The observed data are stored on the server and can be graphically presented with potentially related information, such as environmental information, which is collected over the Internet. The second app, OAK (Observation and Access with Kinect), was developed in our former study and visualizes the location and amount of the body motion using the camera of the smartphone/tablet. This app creates images in a heat map format with a six-color scale based on the frequency of the brightness change, which corresponds to the motion of the user, in each pixel of the captured video. New observation function including the automatic presentation of visual, auditory, and tactile stimuli using IoT technology was additionally implemented to OAK. There were 33 participants, 10 parents and 23 special education teachers, in the experiment. Each participant observed a couple of children with severe multiple disabilities using one of the apps, and there were 27 children in total. The participants were interviewed after the observations.

Key results: TEAK successfully navigated the participants to conduct controlled observation and helped to find previously unnoticed motor or cognitive abilities of several children. Meanwhile, many of the participants requested a simpler technology than the app. This led to a new feature that enables the user to save the observed information via voice using smart speakers (Amazon Echo) or by activating IoT devices (AWS IoT Button). OAK observation also successfully helped to conduct more precise assessment. For example, a non-speaking child's slow voluntary response toward auditory stimulus was identified.

Conclusion: In this study, two IoT-based observation apps were developed, which records and helps to evaluate the responses of children with severe multiple disabilities toward various stimuli presented. The experiments showed that the apps helped to find previously unnoticed responses and gave more precise information of motor and cognitive conditions of the children. The details of each case and how IoT-based technology can contribute to have more effective interactions with them will be discussed at the presentation.

Keywords: IoT, Assessment, Severe Multiple Disabilities, OAK, TEAK.

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IoT-Based Continuous Lifestyle Monitoring: The NOAH Concept

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Background: Among most demanding societal challenges, population ageing is stressing the need for "active" ageing, preserving chances of independent living in the older age. Rescue services, fall detection, telemedicine already proved their effectiveness in increasing self-reliance of older adults living alone: Internet of Things (IoT) technology, providing distributed home intelligence at low costs and low intrusiveness, may open further opportunities. Conventionally, remote clinical parameter monitoring is performed by using specific medical devices; this, however, require schedule compliance and skill and, in the longer perspective, outcomes can be jeopardized by carelessness and boredom. Complementarily, information about meaningful changes in health and wellbeing can be obtained by indirect observation. Many medical conditions, in fact, manifest themselves with behavioral symptoms (e.g., unusual sleeping patterns, or reduced physical activity) which, in turn, can be inferred by tracking home activity, without any action required to the user. This relieves the user from demanding measurement schedules and is suitable for users having no actual skill (e.g., cognitively impaired persons). Inherent challenges come from the need of recognizing relevant features within a continuous flow of unspecific data. User-specific knowledge is needed, which in turn calls for adaptive approaches.

Method: In the NOAH project (funded in the framework of AAL-JP programme), continuous monitoring is introduced, based on a new generation of IoT daily life activity sensors that detect routines as bed patterns, toilet usage, room presence, and others. Such devices exploit the Wi-Fi communication protocol, connecting directly to the Internet, with no need of home hubs. This makes the approach extremely flexible and simple to deal with, supporting personalization and self-management. A suite of cloud-based analytics tools (ranging from statistical analysis to deep-learning techniques) is available to extract meaningful information, such as behavioral trends (either slow or abrupt) and anomalies. Unsupervised analytics is based on the acquisition of user-specific behavioral profile, so that relative changes are assessed, with respect to learned habits. Multivariate clustering techniques are exploited to work out multi-modal profiles, in which multiple customary activity patterns can be accounted for (e.g., related to the weekday, climate or mood). Deviations from such patterns trigger communication with the end-user or his caregiver, by means of simple smartphone apps.

Key results: The NOAH system is being deployed at several users' homes (up to 60 at the end of recruitment phase), in three European countries (Italy, Romania, Belgium). A co-creation process, involving end-users and stakeholders, has been exploited to devise main system features. A large dataset is being collected, onto which the analytics engine continuously performs trend and anomaly detection. Through periodic evaluation (involving questionnaires), effectiveness of the approach, as perceived by caregivers, will be assessed.

Conclusion: The NOAH system aims at continuous monitoring of daily living patterns, based on distributed sensing through innovative WiFi-based devices. Cloud-based analysis tools, based on machine-learning techniques, are exploited to sift through raw data, providing caregivers with meaningful health-related insights. The approach is being field-validated to evaluate its impact in fostering better knowledge, and thus better care.

Keywords: Internet of Things (IoT), Behavioral Analysis, Active and Healthy Ageing (AAL), Sensor Networks.

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Field-based innovation methodology and its implementation on development of an information support robot system for the elderly

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Background: Assistive products with cutting-edge technologies are expected for promoting autonomy and independence of persons with disabilities. In order to improve these developments, conventional design methodologies; e.g. human centered design, design thinking and system thinking; are useful. However, specific development methodologies are sometimes needed especially for non-professionals on assistive product space who have high potential and many technological knowledges. Inoue et.al. proposed field-based development method for assistive products with the 6 steps[1]. This paper describes establishment of a field-based innovation methodology, which is expanded beyond the field-based development method. Then, development of an information support robot system is introduced as an example of an implementation.

Method: Based on the AT development flamework, field-based AT development method[1)] and non-functional requirement perspective, 7 principles was established as a part of the field-based innovation methodology. Then, development project of information support robot for older people with cognitive decline was conducted, according to this methodology.

Key results: Here shows the 7 principles that was established in this study as follows,

1. Set specific target user groups and clarify body function and level of impairment.
2. Collect users' information about daily life and set the use field and stakeholders.
3. Promote user and stakeholder participation into the innovation process.
4. Select suitable human interface technologies based on the users' body function.
5. Measurement of body functions at the real field is recommended for it. In addition, take into account two non-functional requirement as follows,

   a) Modularization and parameter changing function in order to fit to each user.
   b) Prevention against side effects.

6. Fix the AT's concept after clarifying the settings of their use. In addition, take into account two non-functional requirement as follows

   a) Governmental provision system, insurance and other reimbursement.
   b) Market size. Many of ATs are estimated small market.

7. Modify the AT's concept according to the result of the field test using the prototype. Also, develop fitting methods and service systems related to the ATs from the result and knowledge from the field tests.

Based on the data aggregation of the older people's characteristics in the life fields, the robot's functions were identified; e.g. suitable frequency and speed of robot's speech, suitable information transfer method against the cognitive decline, On the other hand, the concept of the robot system was established from the results of group interviews with 124 older people and 40 care professionals and workshop with 2 families and their stakeholders. The fixed concept of the robot system was to indicate important information within daily life e.g. date, day, schedule, through the conversation between users and the robot. Also, service model for the robot system was established. The results of the field tests for one month with 6 older people living in the olders' apartments showed effectiveness on the medication adherence, consolidation of their life rhythm.

Conclusion: This study showed the field-based innovation methodology, and the development of the information support robot system as an example. It was effective on the establishment of useful concept with complicated users, stakeholders and use field.

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Patients experiences with commercially available activity trackers embedded in physiotherapy treatment: A qualitative study

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Background: Activity trackers show potential for use in health care settings, for example in patients with a chronic disease. Guidelines for physiotherapists recommend measuring the physical activity of patients with a chronic disease. The most frequent used measurement tools are questionnaires and diaries, but they have a limited reliability and validity. Activity trackers can overcome these limitations since they provide an objective measurement and record data real-time. Moreover, activity trackers can increase self-management of the patient and eventually save time and money. However, to implement activity trackers in a healthcare process, like physiotherapy, insight into the feasibility from the patient's perspective is needed. Therefore, the goal of this study was to collect experiences of patients with a chronic disease with commercially available activity trackers during physiotherapy treatment and daily life.

Method: In a qualitative study, 29 patients with a chronic disease (COPD, diabetes mellitus, chronic pain, cancer or osteoarthritis) who were receiving physiotherapy used an activity tracker at least two weeks. The following eight activity trackers were selected: Activ8, Digi-Walker CW-700, Fitbit Flex, LumoBack, Moves, Fitbit One, UP24, and the Walking Style X. The participating physiotherapists received training for the possibilities of the activity trackers, and were free to use the activity tracker in any way they thought was best suited for treatment. Experiences were collected using semi-structured interviews and focus group interviews. A framework was developed that incorporated the most important concepts from the experiences of patients by means of a framework analysis. This framework was used to analyse the data from the interviews.

Key results: Participants were between 22 and 78 years old, and 41% of the participants were insufficiently active. The developed framework included seven categories: purchase, instruction, characteristics, correct functioning, sharing data, privacy, use, and, interest in feedback. Each category had several sub-categories. All categories were consistent with the literature used, two new sub-categories were added and four subcategories were removed. The activity trackers motivated patients to increase their physical activity levels and to reach their daily goals. However, participants experienced certain barriers such as high standards goals set by the tracker (10.000 steps) and complexity of the tracker. The complexity decreased their motivation to use the tracker. Participants also missed clear instruction from their physiotherapist about the use and goal of the tracker. Most of the participants did not discuss their data with their physiotherapists, because they placed higher value on the treatment delivered by the physiotherapist. However, participants could see the potential value of using an tracker during their physiotherapy session.

Conclusion: The developed framework gives insight into all important concepts from the experiences with activity trackers for patients with a chronic disease and can be used in further research and practice. In general, patients with a chronic disease were positive regarding activity trackers. However, activity trackers should be adapted to the needs and skills of people with a chronic disease. When using activity trackers, physiotherapists should pay more attention to embedding the tracker in their treatment. Full article can be found: https://www.tandfonline.com/doi/full/10.1080/096382 88.2019.1590470?scroll=top&needAccess=true.

Smartphone Apps to Support the Self-Management of Hypertension: Identification of the Most Suitable Apps

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Background: Hypertension is a common chronic disease in adults that requires effective patients' self-management. Smartphone apps provide considerable potential to play a key role in self-management, evident in the huge number of apps that have become available over the past few years. However, the increasing number of different blood pressure (BP) apps available on the market creates the urgent need for physicians and patients to be made aware of their effectiveness, and the levels of security and privacy that they offer. This will help to identify apps that are useful and safe.

Method: Two studies were conducted to evaluate apps for supporting the self-management of hypertension. Firstly, a systematic review was conducted, including articles from the years 2008 to 2017 that investigated and assessed functionalities of hypertension self-management apps and their effectiveness. Secondly, in January 2018, a content analysis study was undertaken, scanning the most popular UK app stores (Apple and Google Play stores) and describing all available paid and free apps supporting hypertension self-management and examining their functionalities. A privacy and security assessment of potentially effective apps was also performed.

Key results: The systematic review included a total of 21 articles, evaluating 14 apps between them. This review indicated that apps have a generally positive effect on controlling BP. Due to inconsistencies in the design and quality of the articles, there is no decisive evidence about which of the functionality combinations are most effective. However, it is clear that apps are likely to be more effective when they have more

comprehensive functionalities. Most apps in this review were study-specific, that is, they were developed solely for the purpose of the study. This is in contrast to the scores of commercial apps available on app stores. Indeed, the content analysis study identified 186 such apps. There was a lack of evidence in relation to all available apps regarding their usability, effectiveness, and the involvement of health professionals in the development process. Furthermore, only few apps possessed comprehensive functionalities ($n = 30$). Most of them did not meet current criteria regarding data privacy and security and lacked a clear theoretical basis. These findings raise a serious issue for physicians and patients attempting to find a suitable app for the self-management of hypertensions. Eight apps were identified that appeared to be effective, whilst also meeting current standards of security and privacy levels.

Conclusion: Despite the wide availability of apps to support self-management of hypertensive patients, and a corresponding body of research into such apps, relatively few apps are effective in supporting self-management of hypertension and protecting users' personal data.

Keywords: App, Smartphone, hypertension, blood pressure, self-management.

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Developing an Intelligent Virtual Coach for Boccia: Design of a Virtual Boccia Simulator

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Background: According to the World Health Organization, approximately 15% of the worldwide population lives with some form of disability. The current trend indicates that these numbers will keep increasing during the following years. Having a disability can lead to social exclusion, therefore it is paramount to ensure that every individual with a motor or cognitive disability can be able to participate in society, to the largest extent possible. Thus, it is necessary to design and implement innovative strategies in order to tackle these issues by fighting segregation and promoting social integration. Boccia is a precision, strategy-based ball sport which has been part of the Paralympic games since 1984 and it is practiced in more than 50 countries worldwide. Originally, it has been designed for individuals with cerebral palsy, but the rules of the game can be easily adapted to individuals with other types of motor or cognitive disabilities. Besides, Boccia is a multiplayer game, which further encourages the interaction between the players.

Method: This paper presents an intelligent virtual coach for Boccia, which is currently a work in progress. This virtual coach will be able to provide tips to the user by suggesting the best possible position in the court where he/she can place the ball and how to execute the respective throwing movement. Furthermore, the suggested strategies are adapted to the current state of the game. This tool will be used to encourage individuals with different disabilities to learn how to play the game and to help shortening the learning curve, thus promoting physical activity. Furthermore, more individuals will be able to participate in the game and, since Boccia is a team-based game, the interaction amongst players with different disabilities can promote social rehabilitation, thus contributing for inclusion. Moreover, different types of sensors will be used on the players in order to acquire various bio-signals, which may trigger different virtual coach actions/responses. This data will also be recorded, so that relevant health indicators can be closely followed by a coach or a caregiver. The work developed so far focuses on the design of a Virtual Boccia Simulator, which allows to easily simulate various game situations, thus facilitating the training of the virtual coach's Artificial Intelligence algorithms.

Key results: The Virtual Boccia Simulator was successfully developed in Unity 3D. The current implementation allows the user to throw the Boccia balls from each of the six court positions, with the desired direction and force. Ball physics are also customizable. Of course, the setting of these parameters depends on the disability and the associated level. Additionally, a "free-camera" mode was implemented, which allows the placement of Boccia balls anywhere inside the court and the taking of screenshots to be used for the training of Artificial Intelligence algorithms.

Conclusion: Overall, this work in progress aims to encourage the practice of physical activity on individuals with disabilities by playing Boccia, independently of gender, race or religion. Furthermore, as Boccia is a social game, it can be used as a platform for inclusion, empowerment and promotion of social interaction.

Keywords: Boccia, Social Inclusion, Rehabilitation, Artificial Intelligence

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Special Thematic Session 8
Creating a Match: Supporting student participation across the educational continuum with technology

This special thematic session will be an interactive and engaging discussion on examining the role of assistive technology (AT) including universal design for learning (UDL) for students with impairments affecting their participation in educational-based activities. Research supports the use of AT for students with disabilities to access curriculum, enhance cognitive skills, improve communication and social skills, and to aide in independence with self-care and daily living skills. Students with disabilities that begin to use AT early in their educational learning can be more effective in accomplishing their educational goals and transitioning into post-secondary education with increased confidence and success than students being introduced to AT use later in their educational career. Universal design involves a whole systems approach from policy to infrastructure considerations to create a learning environment for all learners to achieve their dreams. Presenters will highlight the importance of addressing AT use across the educational continuum and examine the following areas: early intervention to support learning and child-family engagement, student success in mastering educational goals with a focus on outcome measures, environmental context considerations to support learning, promoting vocational success-the importance of addressing AT and UDL in transition planning for students. Presenters will use the Matching Person and Technology, Ecosystems, and the International Classification of Functioning, Disability, and Health (ICF) Frameworks to discuss the importance of addressing personal factors, environmental contexts, and feature matching of student and technology in the assessment and implementation process. Case scenarios across the education continuum will be used to enhance participant learning.

Chair: *Susan Zapf and Marcia Scherer*

Universal Design as a Catalyst for Transformation Across the Educational Continuum

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Background: A congress can represent many different things to many different people and as organizers of the Universal Design and Higher Education in Transformation Congress 2018 (UDHEIT 2018), our hopes were to allow two communities of practice share a physical space to discuss and debate the transformation of higher education. Each individual journey that the participants of the congress imparted, illustrated the importance and value of a forum for generous thinking – a critical ingredient in sparking innovation and change. The purpose of this presentation is to provide a joint reflection on the impact of this UDHEIT event on our learning – and to present a review of current thinking on how best to employ the principles of universal design at a systems level in a higher education covering the three scales of macro, meso and micro. The overarching framework of the congress was built around a range of key themes capturing the research interests of the diverse communities of practice – from the built environment, digital systems including assistive technologies, urban design and planning, community engagement to curriculum planning and delivery. The key questions to be addressed were at (i) Macro level – how do you influence policy makers and change society for the benefit of all citizens? (ii) Meso level what are the practicalities of developing and implementing policy within organizations and communities? (iii) Micro level how can individual actions and initiatives make a difference? This presentation provides an overview of the research presented by 140 speakers from 30 countries around the world. It provides evidence of innovation, research and critical change that is bringing about an inclusive educational experience for all learners

Method: A thematic review of the papers presented at the UDHEIT 2018 congress to demonstrate how universal design is influencing transformational change in higher education.

Conclusion: Framing Universal Design from a systems perspective enables diverse stakeholders to bridge the "Know-Do" gap. As a vital part of systems change the congress demonstrated, debated and discussed the three critical ingredients for transformation of the edu-

cational environment at an ecosystem level. These ingredients were new resources and materials, changing practices and changing beliefs to ensure an enabling rather than disabling environment for a diverse range of learners.

Keywords: Universal Design, Higher education, transformation, systems approach.

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Developing the Irish Matching Person with Technology (IMPT) to a multimedia format through a Universal Design process

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Background: In Ireland a national study in 2017 commissioned by the National Council for Special Education on the use of Assistive technology (AT) in education recommended that the AT assessment and the matching process should be developed based on the principles of universal design (UD) with an emphasis on pupils with severe and more complex needs. Many children have their own unique abilities and unique understanding of the world which standardised tests often fail to recognise. Exploring the needs of children with disabilities can mean traditional data collection techniques do not provide the framework necessary to investigate how technology and AT can support their needs. Most assessment tools use verbal or text based techniques to interview and assess, which can often position the child as a passive object and do not fully understand a child's experiences or their multiplicity of abilities and needs. This paper outlines the adaptation of the Irish Matching Person with Technology (IMPT) tool to a multi-modal (IMPT/MM) format through a universal design process to provide altnerative inputs, and presents initial findings in a case study series of children who have used the tool in a pre and post study.

Method: A central element of universal design is understanding through observation and ethnography, the experiences of the people, their own perception of their lives, their social interaction and their desired activities, interests, priorities and concerns. In this project the children and their parents were engaged in the whole process through observation, group discussions, focus groups, face to face interviews and engagement within the children in the classroom This was an iterative process developed over 18 months broken down into four stages based on the double diamond 4D design process of discover, define, develop and deliver.

Key results: Sixteen children with multiple disabilities took part in the project with a pre-assessment interview using the IMPT/MM, the children have multiple disabilities with significant learning difficulties. At pre assessment interview, through using the IMPT/MD tool, the children were able to self-identify activities which could be facilitated through AT use, however due to critical problems with service delivery, long waitlists, poor funding and a lack of expertise in AT, just eight children secured assessment. While many of the children are being assessed for one functioning impairment, mainly mobillity, other functional impairments are ignored. This paper presents the findings based on eight case studies, outlining the critical service issues. Work is ongoing to validate the instrument with the remaining 8 children and a further cohort of 10 children.

Conclusion: The use of IMPT/MM enabled the children to self-identify their AT needs, however the project has uncovered critical issues in the delivery of AT service in Ireland which has caused unaccetable delays in the provision of AT and a final report with recommendations will be submitted to the funding body.

Keywords: universal design, assistive technology, matching person with technology, AT service delivery.

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Exploring the Role of Assistive Technologist within a Special Education Setting

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Background: High tech augmentative and alternative communication (AAC) aids remain underutilised and frequently abandoned within special education (SE) schools. Yet there is compelling evidence of both the benefits of early intervention and of the significant contribution these technologies can make towards improving outcomes for emerging communicators with communication disabilities. This study builds upon earlier ethnographic research that identified the cross-disciplinary role of the Assistive Technologist (ATist) as a solution to issues of technical support for pedagogy and co-ordination encountered in the field – a trained professional who might mitigate some of the problems described above by innovating novel solutions, boosting evidence-based practice, and enhancing cooperation between practitioners within the classroom environment. To date there had been no formal attempt to understand or define the ATist role in the SE classroom and this study's primary aim was to explore the role as a precursor towards developing a definitive framework.

Method: Approval was granted from the University Ethics Committee and an ethnographic study was undertaken in a SE school, with the principle investigator (PI) – an experienced AAC practitioner – embedded for five months within a class of primary school age children identified as having profound and multiple learning disabilities (PMLD). An exploratory mixed methods approach was adopted: A qualitative case study (exploratory single-subject design); supplemented by end of study semi-structured interviews with adult stakeholder participants and allied health professionals ($n = 6$) comprising teachers, speech language therapists, classroom assistants and one parent/carer. During the study, the PI worked as part of the team, adopting the role of the ATist, and acting responsively as a mediator between the teacher, focal AAC user and their assistive technology device. Content analysis was then undertaken of the collected data (field notes, transcripts).

Key results: The embedded approach facilitated familiarisation and relationship building. Data yielded support for insights attained in the earlier study, and – importantly – key empirical evidence was acquired, documenting the positive influence of the ATist role as a significant protagonist in coordinating, supporting and meeting pedagogical goals for high tech AAC users. These results represent a major contribution toward the framework currently under development – a definitive description of the ATist's role within a SE context.

Conclusion: The presence of an ATist enabled dynamic personalisation (eg. programming novel vocabulary "just in time") of the focal user's AAC device, which – coupled with frequent, contextual aided language stimulation – created a richer and more responsive learning environment for the focal participant, and concomitantly for staff and for other children in the classroom. The ATist also supported educators in developing tailored online learning activities, and addressing technical issues as and when they arose – both minimising disruption, and supporting a more holistic learning experience for the pupils. For future work, it is intended to complete and evaluate the nascent framework defining the ATist's role in a forthcoming study by eliciting feedback from subject matter experts.

Keywords: Human computer interaction, Augmentative and alternative communication, Early intervention, Special education.

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Assistive Technology in the University, Is There Still a Person-Technology Match?

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Background: The number of persons with disability who study at a university in Spain represents 0.52% of the university's students. That low prevalence is due to several factors: lack of information about Assistive Technology (AT), the low commitment from teachers, deficient accessibility and the self-concept of students with a disability. In this paper, the authors discuss the level of matching student and technology and the predisposition to technology use by university students with a disability, in general, and with Neuromuscular Disorders (NMD) and deafness, in particular.

Method: Results are presented from three studies done in different regions of Spain. The Survey of Technology Use (SOTU), and the Assistive Technology Device Predisposition Assessment (ATD PA) and Educational Technology Device Predisposition Assessment (ET PA) were the measures used and are part of the Matching Person & Technology (MPT) portfolio of assessments. The sample in first study consisted of 155 students with and without a disability; the second sample was comprised of 11 students affected by any

NMD and using wheelchair. In the third sample, 35 participants were students with deafness or hearing impairment (6 prelocutives/prelingual and 29 postlocutives/postlingual).

Key results: The use of specific instruments to measure outcomes, such as those in the MPT model portfolio of measures, is rare in Spain. Just three documented studies have used this tool. The percentage of students with disability in Spanish universities is low, mainly due to lack of accessibility, adaptations, and the absence of assistive technology. The predisposition to technology use, in general, has been positive (number of positive answers was higher than the negatives or neutral). In students with NMD, the scores regarding their match with their wheelchair had a mean of 44.17 (out of 50) and a median of 46.5. Thus, the wheelchair, as an AT, is viewed as benefitting the participation of persons with NMD in their educational activities. Participants scores reflected physical inaccessibility as a main barrier to the optimal use of their AT. Deaf people have very good experiences with technology, especially those with pre-lingual deafness. They rated the video call system as the best support.

Conclusion: There aren't significant differences between students with and without disabilities in regards to their preferences about the use of technology in general. Positive answers to SOTU questionnaire items predominate. The students with disabilities, in general, don't use a large number of ATs during their scholarly activities. The persons with NMD utilize their wheelchair their match with it is positive.

The application of the MPT model and its assessments in a population of 155 adult university students showed good validity and feasibility. This research has allowed for a translation and adaptation of the MPT instruments into Spanish versions.

Keywords: University, Education, Outcome measures, Assistive technology (AT), Matching person and technology (MPT).

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Outcome Effectiveness of Assistive Technology in Supporting Students' Mastery of Educational Goals
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Background: Assistive technology can be a catalyst in supporting students with disabilities to be successful within their educational setting and should be considered within each student's educational plan. The purpose of this quasi-experimental pre-post-test, non-control group research design was to measure the effectiveness of assistive technology tools used in the educational setting to support student success through quantitative analysis using the Student Performance Profile scores.

Method: Twenty-three Assistive Technology Team Evaluators using the MATCH-ACES Assessment evaluated 35 students with disabilities for assistive technology needs. Data was collected during the 2010 and 2011 school years. Specific educational goals were identified for each student and the student's performance pre-scores on these goals were collected. The recommended assistive technology was provided to students with training and students used the technology for a four-six-month time period. Student performance post-scores on the targeted goals were collected and data analyses on outcome effectiveness was completed.

Key results: A significant improvement in student performance was found for this cohort on their educational goals one ($p < 0.001$) and two ($p = 0.001$). A large effect size was found indicating that participants improved their performance on the educational goals related to assistive technology use (goal one [$d = 0.86$], goal two [$d = 0.97$], indicating clinical significance. ANOVA analysis was used to determine if the level of AT use contributed to the student's performance. A Friedman analysis of variance was used due to parametric assumptions not being met (ordinal data). Assistive technology was found to be a significant factor in contributing to the success of student performance ($p < 0.001$). The study was found to have adequate power (power was set at $\beta = 0.80$, effect size: < 0.80).

Conclusion: Assistive technology tools were found to significantly impact students' progress on their educational goals. When students are matched and trained to use assistive technology based on the student's needs and preferences; assistive technology can aid students in making progress on their individualized educational plans and support academic success.

Keywords: Assistive Technology, Students with disabilities, Matching Assistive Technology to Child (MATCH) Assessment, Special Education, Assistive Technology Services.

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Standardizing the Procedures, Improving our Listening to the Needs of the Individual User

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Background: Knowing which elements could guide the development of policies, systems, and service delivery procedures is essential to develop an assistive technology (AT) provision standard, to connect services and outcomes, and compare data for AT in Europe and across the world. As stated by the GREAT conference in Geneva (Global Research, Innovation and Education in Assistive Technology) held in August 2017 as part of the World Health Organization's GATE initiative, identifying what constitute the international framework for the provision of AT worldwide is an urgent WHO task (de Witte et al., 2018).

Method: Developed in the light of the Matching Person and Technology (MPT) model (Scherer, 1998), an ideal model of AT assessment process that gathers the most recent scientific developments in AT assessment and provision is here presented, as it is described in the popular text, Assistive Technology Assessment Handbook, 2nd Edition (Federici and Scherer, 2018). The Matching Person and Technology Model and accompanying assessments have been found to have very good psychometric properties and have been validated by a number of studies. They have been translated into eight languages. Several derivative measures have been developed. In this presentation, we will outline how the AT assessment process can be applied in practice to re-conceptualize the phases of an AT delivery system according to the ICF's biopsychosocial model of disability. The model provides reference guidelines for evidence-based practice, guiding both public and private centers that wish to compare, evaluate, and improve their ability to match a person with the correct technology model. The present contribution to this special thematic session can foster discussion among health practitioners and technology providers (occupational therapists, physiotherapists, rehabilitation engineers, speech-language pathologists), as well as undergraduate and graduate students in these areas.

Key results: Successful assistive technology service delivery outcomes highlighted well the effectiveness of the ideal model, here presented, of AT assessment and delivery process, as demonstrated in several studies (Federici et al., 2015). The environmental assessment procedure brings clarity to measures of accessibility, universal design, and sustainability, and captures well the three perspectives on the interaction between the person and AT in the user's environments.

Conclusion: This model can be used by professionals to check the functioning and to (re-)conceptualize the phases of an AT delivery system according to: (i) the ICF's biopsychosocial model of disability; (ii) the seven steps mentioned by the AAATE as relevant and adequate for any service delivery process; and (iii) the MPT model that ensures that the provision is person-centered and not product of service-centered. This model of service delivery, therefore, intends to express, in an idealized and essential form, an assessment process where persons and their environment are at the core of process, products, personnel, and provision.

Keywords: Assistive Technology Assessment process (ATA model), Matching Person and Technology (MPT) model, ICF.

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**Special Thematic Session 9
Good Practices in AT Service Delivery**

Since the publication of the 2012 AAATE/EASTIN Position Paper on AT service delivery, significant advancements have been carried out in several Countries to improve national policies and service delivery systems. Several new challenges have been posed by the recent changes in the political and socio-economic landscape, as well as the fast technological advancement. The theme "AT policies, systems, service provision models, best practices" has been recently indicated (2016) by the WHO (World Health Organization) among the five research priorities in the Global Priority Research Agenda of the GATE initiative (Global Collaboration on Assistive Technology); it will also be among the topics of the Global Report on Access to AT to be published in 2021 as mandated by the WHO Resolution "Improving Access to Assistive Technology" Issued on May 24, 2016. Within this framework, work is in progress worldwide to develop service delivery models, requirements and standards, drawing on the analysis of best practices either in countries with estab-

lished welfare systems or in developing countries. This session intends to give a feeling of this ongoing work and contribute to the debate by presenting some best practice examples from various Countries; by fostering discussion on commonalities, differences and trends; by helping learn from each other and get inspiration for improvements that can increase access to appropriate assistive technology for persons who need them.
Chair: *Renzo Andrich*

Proposal for Collaborative Assistive Technology Provision with Digital Fabrication

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Background: Assistive technology (AT) services are essential for adapting assistive devices to the individual needs of users with disabilities. The main AT service is selecting or adjusting devices. If neither selecting or adjusting assistive devices are suitable for individual needs, production or remodeling methods can be applied. However, AT services often depend on the empirical knowledge and experience-based skills of individuals or the regional community. Meanwhile, three-dimensional (3D) printing technology is a well-known type of digital fabrication that is expected to result in new value creation. For AT services, we attempted to apply 3D printing technology to actual cases and proposed effective applications. Various case studies have reported the use of 3D printing for supporting special needs education, making self-help devices, and designing 3D printable prosthetics in rehabilitation facilities. Accordingly, human resources development that can take advantage of digital fabrication is required to perform better AT services in local communities where users with disabilities live. In this study, collaborative AT service was proposed through the development of an online database for sharing information about the techniques and knowledge on providing assistive devices to users and a training program for digital fabrication.
Method: The Support System for Assistive Technology (SS-AT), an online database of assistive devices produced using a 3D printer, was created with a cloud database. Each record of the SS-AT contains not only 3D printable files on assistive devices but also tips and empirical information from experts and user feedback including users with disabilities, AT specialists, therapists, designers, and makers, etc. There are two kinds of 3D printable files: those for a parametric approach and an explicit approach. The parametric approach enables the redesign of the shapes of the device by modifying its parameters. The explicit approach enables the design of complex surface shapes to fit to the other parts. The tips and empirical information help adjust parameters and provide suitable AT services. The contents of the training program to learn digital fabrication for AT services were also planned and hands-on workshops were conducted.
Key results: In the SS-AT, various 3D printable files with tips and feedback have been uploaded: joysticks for operating electric wheelchairs and pointing devices, straw clips, keyguards, self-help devices, and shapes of dishes. Although SS-AT access currently requires registration, users can collaborate with each other as well as download files. In the workshop, participants include physical and occupational therapists, special needs education teachers, social workers, caregivers, local volunteers, and AT users with disabilities. They experienced printing an assistive device using 3D printers and designing assistive devices using 3D CAD. Participants also brainstormed self-help devices and shared individual needs and opinions with each other. The results were promising for the development of human resources who perform AT services by remodeling and producing for users with disabilities in local communities.
Conclusion: This work has the good potential to increase AT services in local communities and help share individual experiences, knowledge, and techniques between distant regional communities. It hopes to contribute to the creation of an AT service system using digital fabrication.
Keywords: Digital Fabrication, 3D Printer, Community Welfare.
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Assistive Technology Service Delivery in Rehabilitation Context

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Background: The Italian National Health Service structures the assistive technology (AT) service delivery process in six steps: *planning*, *prescription*, *authorisation*, *delivery*, *inspection* and *follow-up*. Prescription, authorisation and delivery are strictly regulated, under the responsibility – respectively – of a specialized medical doctor, the Local Health Authority and the supplying company chosen by the user. The way to carry out all other steps is left to the service providers. Here we report on the service model implemented by the Fondazione Don Gnocchi (FDG) rehabilitation Centres, according to the conceptual framework developed by the Italian GLIC network of AT Centres.
Method used: This model is based on AT specialized units called *SIVA*, where individual AT interventions are carried out in three steps: *assessment* (leading to the prescription of the appropriate assistive solutions), *verification* (checking the correct implementation of the solution provided) and *follow-up* (measuring its outcome in the long run). Each intervention is tracked through a purposely-developed computerized form (SIVA Form) and three validated instruments: KWAZO, IPPA and QUEST. Each SIVA has an AT showroom, a team of therapists specializing in AT, and can rely on engineering support by a central unit called SIVALab.
Key results: Here we describe the model though an example chosen from the database of the SIVA interventions: Giorgia (fictitious name), a 30-years-old lady with quadriplegia who resides in a residential care facility. The *assessment* was aimed at finding a solution to enable Giorgia to call assistance when lying in bed during the night. The assessment team included a SIVA therapist, a SIVALab engineer and a nurse of the residence. It was found that some residual movements of the left hand and head could be used to operate remote controls. Different solutions were tried out until identifying the most appropriate one: a head-activated pressure switch, positioned near the head through an articulated arm fixed to the bed, and a cable adapter for connecting the switch to the wall socket of the residence call system. An assessment report was compiled through the SIVA Form to recommend this solution. *Verification* was carried out as soon the new solution had been implemented by the care facility. The system had been purchased and installed as recommended. Baseline data for outcome measurement were collected through the KWAZO and IPPA-1 instruments. Three months after, a *follow-up* interview was performed, administering the IPPA-2 and QUEST instruments. Giorgia perceived the solution as very effective (IPPA score $+15$, on a -20 to $+20$ scale), was happy with the assessment/provision service (KWAZO score 4.29 on a 1–5 scale), and was very satisfied with the devices (QUEST score 4.63 on a 1–5 scale). The cost was borne by the residence ($\in$ 660).
Conclusion: Giorgia is an example of how AT interventions are carried out by the SIVA units, and monitored until measuring the outcome in real life situation. This model is used mostly for complex cases where multi-disciplinary work and significant case management effort are needed to ensure consistency of the AT solution with the persons' rehabilitation programme.
Keywords: AT service delivery, AT assessment services, Good practices.
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International Classification of Functioning (ICF) and ISO 9999: 2016 Based Combined Evaluation-effectiveness and Reasoning
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Background: Selection of optimal assessment tool of assistive technology has been talking point among the professionals for years. Standardized tools include often evaluation of limited performance areas in Activity Daily Life skills. Looking for unique basement how to get overview what activities the person with a health condition can do in a standard environment and what they actually do in their usual environment, seems ICF and ISO 9999:2016 combined assessment to be most resultful. State coordinated pilot project is currently in action in Estonia about combined ICF and ISO 9999 assessment prototype development. Current study highlights the results of Estonian version of combined ICF and ISO 9999 based functional assessment. The customer's capacity and performance expressed in following terms: structures (s-codes), functions impairments (b-codes) and activity-participation limitations (d-codes).
Method: 10 persons at the age gap between 35–55 years with Sclerosis Multiplex were selected for

the study, 5 males and 5 females with disability affecting time average 6 years. All participants evaluated as the persons with partial work ability, assessment is based on ICF. Study participants expertise's analyzed about determined ICF codes. Based on work ability assessments participants impairments of functions belonged to the b2, b4, b5 and b7 domains. Activity limitations belonged to the domains d4–d8. All study participants used daily during walking activities lower extremity assistive technology device L300 Go Orthosis, belonging to ISO subcategory 06.15. (Functional neuromuscular stimulators and hybrid orthosis). Before usage and after 3 months of using period of L300 Go device assistive technology specialist assessed participant's motor capacity and performance by ICF and ISO 9999:2016 combined prototype. Overlapping did not exist in 2 ICF subdomains of functioning (b1, b3) and in 2 subdomains in activities (d1, d9). Based on the findings assistive technology specialist created participant's ICF graphic profile with and without assistive technology device.

Key results: ICF based work ability assessment and ISO 9999:2016 based assistive technology assessment are not entirely compatible. There were differences in 2 domains of Functions and in 2 domains of Activity and Participation. ICF and ISO 9999:2016 combination for assessment of person's participation restrictions and activity limitations is most precise. The original ICF Core-Set enables to create functional and activity profile of customer. ICF and ISO 9999:2016 combined assessment enables to create holistic functional profile of customer abilities with and without assistive technology device.

Conclusion: International Classification of Functioning and ISO 9999:2016 based combined assessment is beneficial for setting goals and performing holistic rehabilitation as it enables to focus simultaneously to the customer's functional performance and capacity. Customers graphic profiles created by two-component assessment are valuable and synoptic data sets of customer's functional abilities and skills.

Keywords: Functioning, Work ability, Performance, Capacity.

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Exploring SMART Technologies: The Value of Tailored Sessions

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Background: There is an ever-expanding range of mainstream and dedicated technologies on the market. In particular, innovations such as SMART technologies (Sensing, Monitoring and Automatically Responding Technologies (SMART) provide increasing opportunities for older people and people with disabilities to manage and monitor their homes, maintain safety and security, promote health, navigate through environments, and remain connected to their communities. However, it is often difficult to keep abreast of new developments and understand what these technologies can offer. A qualitative study was undertaken to examine the experiences of 12 people with a variety of abilities who partnered with a health professional to explore the opportunities afforded by SMART technologies. This presentation reports on the experiences of their individualized SMART technology exploration session, including their awareness of these technologies, motivations for acquisition, and perceived barriers and facilitators to the uptake and use of these technologies.

Method: Participants were provided with an individualized session to explore SMART technologies and evaluate the opportunities these afforded them. The sessions were audio recorded and transcribed verbatim. Following the session, participants were phoned and asked a series of questions relating to what worked / didn't work well in the session in terms of understanding what was possible and what these technologies might offer. The participant's awareness of SMART technology, motivations for acquisition, and perceived barriers and facilitators to uptake and use were also examined through a thematic analysis of the session and interview transcripts.

Key results: Twelve people with disabilities were involved in the study. The participants ranged in age from 12–74 years and had a variety of disabilities and health conditions including congenital (1) and degenerative (4) neurological conditions; traumatic injuries (2); vision impairment (1); three other health conditions (4).

Participants reported that a comprehensive overview of SMART technologies presented in functional categories helped them to understand what was possible and the potential value of these technologies to their lives. Expectations of how well things were currently being managed often changed during the session, as

people were made aware of the contribution SMART technologies could make. Participants reported that demonstrations of the technologies helped them understand the functions they offered. Tailoring information to each individual's specific requirements and circumstances kept participants engaged and wanting to know more.

The main influences on awareness and knowledge of SMART technology were reported to be general level of interest in technology and avenues for gaining information. Motivations for acquiring SMART technologies included future planning, leisure participation and social interaction, portability, personal safety, and independence. Barriers and facilitators to uptake and use, included reliability and durability, lifestyle fit, cost, learning to use SMART technology, ease of use and environment and contextual factors.

Conclusion: Tailored SMART technology sessions which overview the range of technologies in functional categories extend an individual's understanding of how these technologies can enhance his or her life and create new opportunities. These sessions should also give due consideration to people's motivations for exploring these technologies and perceived barriers and facilitators in order to promote uptake and use.

Keywords: SMART technologies, tailored session, uptake and use.

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What are They Doing and What are They Measuring? A Scoping Review on the Technological Interventions and Ageing in Place Outcomes Allied Health Professionals Use

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Background: Technology is often recommended in the scientific literature and by governments as a way of supporting older adults to "age in place". That is, to live independently in a way of their choosing. Despite such emphasis on technologies, and the exponential rate in technology development and availability, there are still many gaps in the use of technologies within the aged care sector. Specifically, little is known about how allied health professionals working with older adults deliver technology to facilitate their client's independence, with the majority of research focusing on the development and accessibility of technologies rather than the impact on person-centred outcomes associated with ageing in place.

The current study thus explores (1) how allied health professionals are currently using technologies with older adults, and (2) the outcome measures used to the assess the impact of technology on ageing in place.

Method: A scoping review was conducted using recognised methods. Studies were included if they used a quantitative design to evaluate the effect of a technology which may be recommended by an allied professional and who's outcome was to increase an older adult's independence, wellbeing, confidence or participation in everyday activities. 12 relevant health databases were searched for peer reviewed, intervention studies, published between 2008 and 2018. Key search terms included, technology, older adult, community, and their synonyms. Articles were independently screened and assessed for inclusion in the review. Key data were then extracted from each included study, with the findings from each study compared for similarities and differences.

Key results: Forty-seven studies were included in the review. Many of the excluded studies focused solely on uptake and acceptability of the technology or on clinical outcomes, rather than improving outcomes related to ageing in place. Human interactions and social connections appear important, particularly in learning and using a new technology. Most of the studies focused on a particular technology with few studies focusing on the individual goals of the older person in relation to ageing in place.

Conclusion: Peer reviewed studies have been published evaluating the effect of technology on some ageing in place outcomes. This study provides an insight into the current techniques and practices of allied health professionals when using technology as an intervention, and the types of outcome measures used in relation to ageing in place. These findings can inform the design of a meaningful and effective process for allied health professionals to use when considering technological interventions for older adults. In practice it is important to work with a person-centred approach, matching technological interventions to suit the goals of the older person and the context.

Keywords: Aged, Technology, Health Professions, Community, Outcome Measures.

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Assistive Technology Provision in India: Challenges and solutions

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Background: Provision of Assistive Technology (AT) to a country of 1.35 billion people; 70% of them spread over 640,867 villages is an enormous challenge. Even if just a third of the 26.8 million of the estimated number of persons with disability (PwDs) in India needed AT, it is still 8–10 million people that have to be reached. Despite mammoth efforts taken by the government, complemented by private business enterprises, not-for-profit and philanthropic organizations, AT provision in India is still fragmented and mostly unregulated. Access to good quality, affordable AT, remains a dream to many of the persons with disability. The objective of this paper is to present the various efforts and programs developed by the government and the private sector, its benefits and challenges and suggest a simpler model that could be effective and efficient to fill the gap of AT needs in India.

Method: The different models of AT provision in India was reviewed using a combination of a desk review, literature search and sharing of learning from being an implementer of the government District Disability Rehabilitation Centre over the past five years. This has given the opportunity to gain rich insights on AT provision through multiple interactions with PwDs, grass root level rehabilitation workers, government officials, private sector and other organizations who are involved in AT provision and rehabilitation.

Key results: The Ministry of Social Justice and Empowerment (SJ & E) proposed to establish the District Disability Rehabilitation Centers (DDRCs) to serve as "Hubs for comprehensive rehabilitation" in all 640 districts in India. The provision/fitment of assistive devices, follow up/repair of assistive devices is an important component of the DDRC. Besides the DDRC, most ATs have to be obtained through the Assistance to Disabled Persons (ADIP) Scheme. However, the process of procuring ATs through this scheme is extremely complex with extensive documentation, upfront payment by NGOs, prolonged turnaround times, delays in reimbursement and poor quality of ATs supplied. The Artificial Limbs Manufacturing Corporation of India (ALIMCO) supplies assistive products that come is standard sizes and are not "tailor made" to the needs of the disabled, leading to non-utilization and waste of resources. The DDRCs themselves are plagued by lack of sufficient funds, adequately trained manpower, materials and poor co-ordination at various levels and sectors. The private sector on the other hand has contributed considerably in research and development of various assistive products, but they are islands of excellence in a sea of poverty and inaccessibility.

Conclusion: AT provision through the DDRC model could be strengthened with more political will, infusion of more resources, improving the competency of staff, better monitoring, supervision and better collaboration with the NGO/private sector. Simpler processes in obtaining ATs through the existing schemes would improve access and affordable to the majority of the PwDs. The social, economic, cultural diversity, poverty and inequity of India contribute to the complex challenges in AT provision in India.

Keywords: Assistive Technology, India, challenges, solutions, DDRC.

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Assessing the Outcome of Individual Assistive Technology Interventions

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Background: Assistive Technology (AT) outcome is indicated by the World Health Organization among the five top priorities in AT research. In recent years several measurement tools have been developed and validated in many languages. One of today's key issues is how to routinely include outcome measures within the service delivery process, in order to capture the effectiveness of the intervention in a sustainable manner (i.e. compatible with organization, human resources and budgetary constraints) and detect possible cases of ineffectiveness that require further intake.

Method: 57 persons (27 women, 30 men, age 5–88 average 59) – who had received AT solutions after in-depth assessment in specialized AT units of rehabilitation centres – were recruited to undergo a verification/follow-up process. Each assistive solution included a range of products and environmental adaptations to facilitate mobility, communication and self-care in daily life at home, work or school. Overall 150 products were provided, mainly manual or powered

wheelchairs, seating systems, walkers, hoists, computer access interfaces, bathroom devices and communicators. Verification included: 1) inventory of the products composing the assistive solution; 2) technical inspection to check proper installation/fitting; 3) KWAZO (Quality of AT Service Delivery Process) questionnaire about the user's and the caregiver's perceived quality of the assessment and provision service; 4) IPPA (Individual Prioritised Problems Assesment) first interview to detect their expectations with the received AT solution and 5) WHODAS (WHO Disability Assessment Schedule) 12-item interview to detect the user's disability profile.

A follow-up interview was carried out 3 to 6 months after verification. It included 1) data on the product usage; 2) possible problems occurred in usage; 3) IPPA second questionnaire to detect how far the user's expectations had been met; 4) QUEST (Quebec User Evaluation of Satisfaction with AT) to detect the user satisfaction with each product.

Key results: Most persons had severe disability condition (WHODAS score 33–100%, mean 67%) especially in the mobility area. All persons expressed high satisfaction with the process (KWAZO user score 3–5, mean 4,75; caregivers score 4–5, mean 4,79; in a 1 to 5 scale); most persons perceived their AT solution as effective (IPPA user score $-5,8 - +20$, mean $+8,45$; caregiver score $+0,83 - +16,43$, mean $+9,14$; in a -20 to $+20$ scale); most person scored the products included in the AT solution as more than good (QUEST user score: 2–5, mean 4,49; caregiver score 3–5, mean 4,55; in a 1 to 5 scale). Three cases were found ineffective (IPPA $<= 0$); the failure reasons being, respectively 1) unexpected worsening of clinical condition 2) changes in living environment and 3) technical inadequacy of the provided products.

Conclusion: This method proved effective in measuring the outcome of AT interventions, and distinguishing among successful cases, unsuccessful cases (therefore needing to be looked after again) and "neutral" cases (where seemingly no improvement was achieved). More cost-efficient tools should be designed for the follow-up interview in order to make it sustainable within the service delivery process. Currently, work is in progress to routinely include this method in the service protocol of these rehabilitation centres.

Keywords: AT Assessment, AT service delivery, AT Outcome measurement.

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Assistive Technology Service Delivery models in the Netherlands

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Background: Since 2002, models to guide the Assistive Technology Service Delivery (ATSD) in the Netherlands have been implemented with the aim to organize the provision of AT in a more client-centered way. Due to the fact that the funding of AT is regulated by different laws and statutory rules, ATSD is perceived as very fragmented and not easy to oversee. Not only the type of AT but also the individual situation of the user and the setting of use determine which law or rule is applicable. The objective of this paper is to present the developments, recent trends and current practice of ATSD in the Netherlands, including advantages and disadvantages as identified by different stakeholders involved.

Method: A desk research was conducted by Internet search, with a focus on websites and documents of the Dutch government, knowledge institutions, the Netherlands Organization for Health Research and Development, and a large Dutch patient organization. Additionally, an invitational conference was held and 60 stakeholders representing experts in the field of ATSD, such as users, policymakers, researchers, suppliers, and practitioners with a variety of professional backgrounds were consulted, using a metaplan method.

Key results: Four main laws and corresponding executive authorities are involved in the provision of AT.

On the one hand, the Social Support Act and the provision of AT based on the ICF offer advantages compared to the previous situation in which a list of AT products existed that showed which products could be funded by indication. Now a person's needs in functioning, desired activities and participation form the starting-point to realize an optimal match between the person and a specific product, based on a program of requirements. Stakeholders are provided with the possibility of choice, and innovations in the field of AT are facilitated. Current models of ATSD emphasize the importance of trying-out, instruction, training, and user-centered assessments during the evaluation and follow-up. On the other hand, AT services are delivered at dif-

ferent places with no coherence. This is problematic when it comes to transitions between different care-settings (e.g. from hospital to a rehabilitation ward of a nursing home and finally, going back home) as different laws and regulations are involved. This renders the ATSD quite complex and time consuming. The same holds true for situations that demand a combination of AT devices which are funded by different executing authorities. An example is a dynamic arm support mounted on a wheelchair. Furthermore, the potential of AT is not used fully. One reason for that is a lack of awareness of the possible benefits of AT and different types of AT solutions, and missing objective information and protocols to guide their selection. Another reason is that the preventive or supportive use of AT by (in)formal caregivers is hindered by the conditionality of the Social Support Act, with costs being decisive instead of AT's added value.

Conclusion: Despite the identified drawbacks and deficits in daily practice the underlying user-centered principles of currently used ATDS models could be recommended as good practice in ATSD.

Keywords: Assistive Technology Service Delivery, ICF, user-centered.

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Special Thematic Session 10
Play, Children with Disabilities, and Robotics. State of the Art and New Developments

Play is the crucial activity through which children acquire psycho-motor, cognitive and social competences. Children with disabilities (CwD) may face many barriers to play, such as inaccessible environments and toys or adult attitudes often prioritizing rehabilitation and/or educational goals rather than to exploit children's ability to freely act and participate. Robotics has long faced this topic by developing robotic toys, assistive technology to enable play, and social assistive tools for the play of CwD. Robots can support both the activity of playing and the collection of data about the activity of CwD, possibly offering to the caregivers or companions the chance to develop new playing activities. Often, robots provide new opportunities of play that could be exploited to obtain interesting achievements. How robots can support play for CwD? What robots can bring to play for CwD? What products are available andare being developed? Is accessibility a hot topic? What developments are awaited to radical change and support CwD's play? The STS will show

the work of some prominent groups working in the field, sharing the idea that CwD must have the opportunity to play autonomously the type of play they can/wish/need to grow up fully and happily. In particular, it will present: prototypes of new toys, augmentative mobility and augmented manipulation enabling children's autonomous play, experimentations of mainstream robots in school and in rehabilitation contexts, together with Guidelines on accessibility and usability of robotic toys. Inclusive contexts of play will be discussed too, showing how robots could improve inclusiveness.

Chair: *Serenella Besio*

What Is Play in Robotics Today?
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Background: Play is an innate, internally driven and evolving activity, crucial for children to acquire psycho-motor, cognitive and social competences. Despite being a right, it is far from being achieved by Children with Disabilities (CwD), who may face many barriers to play, such as inaccessible environments and toys or inadequate adult attitudes. Robotics has long faced this topic, by developing toys, assistive technology and social assistive tools for the CwD's play; here, play is interpreted as an unavoidable mean towards health, rehabilitation, educational scopes. Do these studies share a unique definition of play? What kind of awareness do they show on the different play types and characteristics and their relationships with the different ages in life? Last, are these studies comparable on a common basis, so that the field of play for CwD can steadily grow and acquire new knowledge? This presentation aims at giving an answer to these questions, according to the COST Action "LUDI – Play for CwD" (2014–2018) framework. Through the work of 100 European researchers and professionals, LUDI created a comprehensive theoretical background on the theme of CwD (Besio et al., 2017; 2018; Encarnção et al., 2018), to support further transdisciplinary research. By analyzing the studies and products found in the literature, it will be possible to propose some innovative reflections on the possible roles of robots for the CwD' play, and on awaited developments to produce a real advancement in the field.

Method: The last ten years (2009–2019) Proceedings of six important international robotics conferences

(EPIROB, HRI, ICRA, IDC, IROS, ROMAN) have been searched with the keywords "child" AND "play" OR "game", to know: a) the distribution of the related studies along the years; b) how many studies are addressed to children with disabilities (and what kind of impairment); c) what definition and/or theory of play is adopted, if any; d) what role is attributed to play and what system abilities are implemented for this purpose.

Key results: After relevancy check, 112 studies were found, with two peaks around the years 2013–14 and 2016–17; 19.6% are devoted to CwD (half to autism spectrum disorders). ROMAN, IDC and HRI are the most represented; 3 keynote speeches have been devoted to child's play (one to CwD). About half of the articles presents prototypes, the other ones adopt existing robots in original experimentations. They mostly address human-computer interaction aspects, mainly emotional, on the two sides; implemented relationships include the robots as companions, tutors, tutees, co-players. No article proposes a definition of play, 3 refer to play types. Health and educational topics are highly represented, for children with and without disabilities. Unexpectedly, one keynote speech was devoted to play for the sake of play.

Conclusion: The need for the adoption of a shared framework on child play, particularly for CwD, is testified by these scattered studies facing the topic from different perspectives without taking advantage from the others' results. By applying the LUDI approach, the presentation will show the most crucial deficiencies in the field and will advance some proposal for future implementation.

Keywords: Play, Children with Disabilities, Robotics.
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Simple Robots for Simple Play: Exploiting the Resources in Real Situations

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Background: Play is a right and a tool for development for everybody (Besio, 2017). Physical, interactive objects, i.e. robots, can provide tools engaging the player in a pleasurable activity. Pleasure and engagement come from the right mix of challenge and reward (Csikszentmihalyi, 1997). Complex and expensive devices are not needed for this: well-designed devices exploiting appropriate sets of signals and cause-

effect relationships are enough to provide effective and interesting play experiences. A key modality to obtain these devices is to co-design the robot, involving players and their care-givers, which provide needs and desiderata, together with designers and technicians that can provide technological solutions. We developed several robots to be used by people affected by NDD (http://playbot4all.polimi.it). As an example, we present here Scimmiottondo, a monkey plush, having two metal hands. When touching both the hands the robot starts singing a typical Ring-around-the-rosey song. This can also be obtained when a set of people forms a circle including Scimmiottondo. In this way, it has been possible to include up to 10 people with different NDD, together with normally developed people, and therapists in a play activity exploiting attention, turn-taking, and physical contact. Scimmiottondo also includes an accelerometer, and, if it is mistreated in any phase of the game, it can start screaming. Moreover, if it is caressed on he top of the head it can sing a special song.

Method: The design of the robot was started by mentioning to a psychologist some technical possibilities, recognized as potentially interesting, and then the robot was co-designed with a care center. The participants to the trials were recruited by their caregivers. Each session started by a free interaction with the robot, aimed at discovering its capabilities and experiencing cause-effect relationships. Then, it was introduced as a possible companion for the Ring-around-the-rosey game, and the players had their moments to autonomously try what happened when they formed the complete circle or opened it, taking turns to experience to obtain the desired effect (singing or stop singing). Scimmiottondo was used in 10 sessions including 6–10 people with different NDD (medium functionality, aging from 16 to 42), 2–3 therapists and 1–3 normally developed people. Results were collected by interview from therapists.

Key results: Therapists reported the success of the experience in activating the game and stimulating appropriate interaction even in subjects usually refusing physical contact or having problems in managing turn-taking. Scimiottondo could focus the group activity also in repeated sessions, thanks to its appropriate engaging level.

Conclusion: Even very simple, cheap robots, such as the ones we designed to implement simple cause-effect relationships, can produce interesting experiences with people with different NDD. Critical issues include the perception of signals and the exploration of cause-

effect relationships; these call for the selection of appropriate signals, which should be reliably perceived and properly produced by the robot. The basic functionalities can be discovered by free exploration and can make also unexpected behaviors arising, a sign that NDD players can exploit their inventive power and show their hidden abilities.

Keywords: Play, Robot, Interactive system, Co-design, NDD.

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Play and Augmentative Mobility: the INMAC (INclusive Mobility for All Children) Vehicle

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Background: Children with Cerebral Palsy (CP) usually do not have the possibility of fully engaging in Play activities, mainly due to their functional limitations that lead to severe restrictions to perform manipulation and mobility events. For many years, activities of independent/augmentative mobility in Children with Disabilities (CwD) have been performed through the use of powered wheelchairs available in the market. However in the same markets, and with very few exceptions, there wasn't available any equipment to specifically provide augmentative mobility with the main objective of allowing very young CwD to engage in Play activities, adequate and/or adapted to their age levels. As a consequence, and in order to overtake some of the functional limitations faced by children with severe disabilities when they want to be involved in Play/Mobility activities, a R&D Project was set-up with the main objective of providing independent mobility to CwD, with an emphasis on CP Children. As a result of the project, a special vehicle – INMAC INdependent Mobility for All Children – was developed and a few industrial prototypes of that vehicle were produced.

Method: INMAC is the practical outcome of an international R&D Project developed in order to fabricate a working prototype of a vehicle that could allow any child aged from 1 to 6 years old, namely those with severe disabilities, to engage in Play. INMAC is equipped with an array of ultrasonic sensors that not only avoid obstacles, but also provide feedback to the enduser of the physical environment where it is used. The vehicle can be totally controlled by the

child through a specifically developed console and/or any AT interface available in the market. Five levels of use/activity can be setup, from a first level where the vehicle "takes over" the mobility tasks to be performed, until a fifth where it is the child that takes full control of the vehicle. Several prototypes were developed and tested in Rehab Centres mainly with CP children, and finally an industrial prototype (ready to be fabricated and go to the market) was developed, allowing any of the specific AT interfaces existing in the market (direct or indirect selection) to be used. The vehicle comes with a specially developed software that not only allows five levels of use/activity to be setup, but also allows the acquisition of many important data both from the vehicle as well from the specific interface used by the child. A protocol was developed for the tests of the INMAC, that mainly took place at a specialized rehab Centre for Cerebral Palsied Children, in Lisbon, Portugal.

Key results: Preliminary conclusions of the tests, showed that not only the children were able to be fully engaged in play activities despite their severe functional limitations, but also it contributed to the acquisition of psyco-motor, cognitive and social competences to those children.

Conclusion: Further tests are planned at an international level and with children with other disabilities than only PC children. Possibility of fabrication of many more vehicles to be available in the international market, are one of the outcomes of this project, contributing for the availability in the overall market of specific AT solutions for independent mobility.

Keywords: Children with Disabilities and Play, Augmentative Mobility, Independent Mobility.

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Mainstream Traditional or Robotic Toys: Which of Them Better Supports Playfulness in Children with Disabilities?

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Background: Play is the main drive for development and is fundamental for physical, cognitive and social development (Piaget, 1945/1972; Vygotsky, 1976). Playfulness is the child's 'disposition to play' (Barnett, 1991). Playfulness can allow to discriminate between play for the sake of play and 'play-like' activi-

ties (Visalberghi, 1958), which occur when play is used as a means to achieve 'other' purposes, such as learning or skill improvements.

Children with disabilities can experience limitations and functional problems (intellectual and motor limitations, speech disorders, sensory disturbances, emotional and social difficulties; Tingle, 1990). For these children, play can be limited because of environmental and contextual barriers (Besio, 2017); moreover, play is often used as a means for rehabilitation or educational purposes. Thus, children with disabilities are often prevented from playing for the sake of play. Toys, and specifically robotic toys, can offer interesting solutions to overcome the limitations of play activities and to support Playfulness (Skär, 2002). The project GioDi-1 (2014–2015) showed that robotic toys could support play and playfulness in children with physical impairments (Bulgarelli et al., 2018). The project GioDi-2 (2017–2019) directly compared the impact of similar classical vs robotic toys on the child's playfulness. The current study reports the first results of GioDi-2. The hypothesis was that children would obtain higher Playfulness scores when using robotic toys compared to classic toys.

Method: The sample consisted in 10 children (7 girls, 3 boys; mean age in years = 9.24, SD = 2.51; min = 6.05 years, max = 12.73) with intellectual disabilities; three children had also physical impairments. Data were collected in Fall 2018; each session was videotaped. Children were observed at school, in a separate room, during three sessions, playing with an educator with six different toys: classic and robotic caterpillar, classic and robotic dragon, classic and electronic ball. Fifty-eight sessions were analysed (one child refused to play with the robotic dragon, and one child with the classic caterpillar). Two independent observers coded the Test of Playfulness. Inter-rater agreement had been measured and disagreements had been solved.

Key results: The ToP scores varied from -2.40 to 2.40 (mean score $= 0.25$, SD $= 1.26$). No significant differences in the Playfulness scores were observed comparing the use of classic and robotic toys (mean ToP score_classic $= 0.29$, SD $= 1.32$; mean ToP score_robotic $= 0.20$ SD $= 1.23$, $p > 0.70$). The differences between the Playfulness scores were also analysed for: a) each child: one child only (male, age $= 7.75$, with intellectual and physical disabilities) obtained a higher Playfulness score when using classic toys than robotic toys; b) each toy: no significant differences were observed (all $p > 0.05$).

Conclusion: First results showed that robotic toys did not support playfulness more than classic toys. Future analyses will deepen the association between the usability and accessibility of the toys and the severity and characteristics of the disabilities. Moreover, the play partners' competence in supporting play and playfulness will be analysed as well.

Keywords: Play, playfulness, robotic toys, intellectual disabilities.

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Guidelines and Tools on Usability and Accessibility of Toys and Technologies for Play for Children with Disabilities: Review and Proposal from the LUDI Project

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Background: Play is important for each child. Toys, games, apps, robots and other technological products can elicit great play opportunities. Moreover they can create inclusive play and support children with disabilities often challenged among others in playing different play objects. However finding, choosing, evaluating, designing or producing a toy or technology usable for all children can be a struggle. Professionals working with children with disabilities as well as designers and engineers might benefit from guidelines or tools on usability and accessibility of toys and technologies.

Method: Within the LUDI project, COST action TD1309, a scoping review was carried out to answer the following questions (1) which guidelines and tools regarding usability and accessibility of toys and technologies for play for children with disabilities exist? (2) what is their possible use for different stakeholders involved in play for children with disabilities? and (3) what are the strengths and the weaknesses of the guidelines and tools? Four different sources were consulted: LUDI database (stored at: http://ludi.utad.pt/), collected sources of LUDI members, experts in the field of play for children with disabilities, scientific databases and hand search.

Key results: The search yielded 15 sources on usability and accessibility of toys and technologies for play for children with disabilities. An in-depth review with an adapted version of the AGREE II instrument

gained 10 suitable guidelines for designing, producing, choosing or evaluating toys and technologies on usability and accessibility. Five of these had a focus on play. From these ten guidelines four were related to persons with disabilities. The topic of these guidelines was: games/apps (6), toys (1), indoor playthings and environment (1), generic principles (1), all kind of toys and technologies for play (1). Only guidelines with recommendations for a specific stakeholder group with a specific play object (games or toys) were found. Tools such as assessments, checklists were not emerging from this scoping review. No guideline neither a tool about usability and accessibility of a robot for play for children with disabilities emerged.

Conclusion: Based on these results, it was decided to develop a guideline for different stakeholders about usability and accessibility of toys and technologies for play for children with disabilities. The choice for a focus on stakeholders and not on a specific technological product, i.e. robots, was based on limited availability of research data about robots for play for children with disabilities and the wish of stakeholders to address play objects in general. The different guidelines reflect the expertise of LUDI members including their network in pragmatic documents with reflective questions to support the decision making process of the user. In these newly developed guidelines the results from the scoping review were incorporated. A small feasibility study gave an impression about first experiences and opinions of potential users of the guidelines in different European countries.

Keywords: guidelines and tools, usability, accessibility, toys and technologies, children with disabilities.

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Taking Integrated Augmentative Manipulation and Communication Assistive Technologies to Daily Intervention Practice

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Background: Children with motor impairments may have difficulties in manipulating objects impacting their participation in play and academic activities, thus affecting their cognitive development. Lego® Mindstorms® controlled through augmentative and alternative communication (AAC) devices has been used to build integrated augmentative manipulation and communication assistive technologies (IAMCATs). IAMCATs allow children to communicate while using the robotic tool for indirect manipulation, building on their expertise with the AAC device and access method. They also provide a means for children to demonstrate their abilities, opening a window into children's skills. IAMCATs have been used to support: a) participation in free and directed play; b) participation in mathematics, language, and science & social studies academic activities; c) training assistive technology indirect access methods (scanning). This paper reports the first steps in taking IAMCATs to daily intervention practice at the Calouste Gulbenkian Rehabilitation Center for Cerebral Palsy (CRPCCG) in Lisbon, Portugal. This center accumulates more than 45 years of experience providing rehabilitation services to children with disabilities, combining clinical practice with clinical research.

Method: In order to define the requisites of an IAMCAT to be used in daily intervention with children with neuromotor impairments, a Research Assistant spent one month at the CRPCCG. The IAMCAT developed in a previous project was used to exemplify what may be the features of such a system. Through informal conversations with the center clinicians, possible uses for the system were identified. Eight children with neuromotor impairments aged 3–9 years trialed the IAMCAT in semi-structured play activities in three levels of difficulty.

Key results: Clinicians at CRPCCG identified several possible interventions in which the IAMCAT could be useful, including play, development of visual-spatial perception, anticipation and planning skills, increase attention span, cause-and-effect and turn taking training. Challenges mentioned include the need for having a) easy-to-follow operation instructions, b) a playful training protocol for children, c) different operation scenarios, and d) intervention protocols for the different intervention goals. Children were curious about the IAMCAT and willing to try it. Due to their ages and the lack of training on the use of the IAMCAT, participants

were only able to perform the simplest tasks. Five of them used trial-and-error strategies to perform level 1 tasks (e.g., make the robot move). Three were able to drive the robot to a given location without obstacles (level 2 task). None was able to accomplish a level 3 task (e.g., avoiding obstacles). Nevertheless, observation of children using the IAMCAT confirmed the potential of the tool.

Conclusion: An IAMCAT can be a useful tool in a rehabilitation center to help achieving different intervention goals. Challenges identified may be addressed by an appropriate translation of research results into protocols that can be implemented in day-to-day interventions. Future work includes the deployment of a website containing detailed but easy-to-use operation instructions and intervention protocols, and then systematically follow their implementation in daily interventions at the CRPCCG. Properly documenting the interventions will allow for more robust conclusions on the use of IAMCATs in daily intervention practice.

Keywords: Integrated augmentative manipulation and communication assistive technologies, robotic assistive technologies, neuromotor impairments.

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Playing with ZORA – Robot supported therapy and education for children with severe physical disabilities

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Background: Play is of crucial importance for the development of a child. Especially children with severe physical disabilities may experience difficulties in play and they often need assistance while playing. Play activities may be partially or entirely impossible for these children e.g. manipulation toys, or accessing playgrounds. New developments in the field of technology and ICT create new opportunities which may improve the play possibilities for these children. This paper presents the results of a study using robot ZORA for children with severe physical disabilities in therapy and special education. The contribution of ZORA to the achievement of therapeutic and educational goals

and the roles professionals attributed to ZORA were examined.

Method: A mixed methods approach was used and was conducted among children with severe physical disabilities, in multiple rehabilitation and special education environments. Over a period of six weeks, children played and practiced with ZORA six times in either individual or group sessions. Professionals (therapists and teachers) attended a ZORA training session, decided for which goals they would like to apply ZORA and designed specific scenarios with the researcher and IT expert. Previous research indicated that ZORA can contribute to goals within the domains of movement skills, communication skills and cognitive skills, therefore professionals selected goals within these domains. The Individually Prioritized Problem Assessment (IPPA) was used to assess to what extent the individual goals were reached according to the professional. Furthermore, playfulness and the children's experience of the sessions were assessed using a visual analogue playfulness scale (range 0–10) and smileys (like, neutral or dislike). Video-stimulated recall interviews were used to gain insight into the different roles of the robot during the sessions. The IPPA and playfulness data was analyzed using descriptive statistics. The interviews were transcribed, labelled and coded.

Key results: In total 33 children (11 girls, 22 boys) with physical disability participated in this study. The chronological age of the children was 2 to 21 years old, and their developmental age was between 2 and 8 years old. Twelve professionals took part by preparing and leading the sessions and taking part in the interviews. A significant difference was found between IPPA before and after the intervention sessions ($p = 0.001$), which indicates a positive contribution of the ZORA-based intervention sessions to the achievement of goals. Looking at specific domains the largest contributions were found on the domains of movement communication skills. The average score of playfulness of all sessions taken together was 7.5, indicating that ZORA elicits play. Overall, the children liked playing with ZORA, since they chose the 'like' smiley in 93% of the sessions. The most suitable roles of ZORA according to the professionals are the roles of motivator, rewarder and instructor.

Conclusion: This study indicated that robot ZORA can be an effective tool to be used in rehabilitation and special education to reach therapeutic and educational goals. ZORA in particular, and robots in general, may offer the next generation of play for children with severe physical disabilities.

Special Thematic Session 11
Innovative Approaches in Building Inclusive Educational Environments with Technology

Building inclusive education environments in the digital era entails numerous opportunities as well as many challenges. Additional aspects of integrating (assistive) technology in education are added towards the goals of digital inclusion that need careful management and monitoring. Digital literacy for all learners becomes a substantial aspect of the use of technology in order to create inclusive learning communities, as this is also defined by the UN Convention for the Rights of People with Disabilities. Recent research evidence, such as the work of the ENTELIS network, yielded a number of considerations but also highlighted a number of opportunities for overcoming barriers and reducing the digital divide. The discussion around digital divide, especially for learners with disabilities, does not solely concentrate on the technological dimensions and lack of access to technology resources, but it is aligned with the current conceptualization of inclusive education. Self-assessment, action research and reflective practice are becoming renowned approaches for defining goals and monitoring progress towards digital inclusive education. This special theme aims to explore some examples of such approaches when using technology for inclusion and to discuss considerations and opportunities involved.

Chairs: *Katerina Mavrou and Silvio Pagliara*

"Nothing about Us without Us": Next Level

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Background: Education is a prominent facilitator of inclusion amongst up-to-date Information and Communication Technologies, Assistive Technologies and (e)Accessibility. While there is a most complete corpus of initiatives, guidelines and regulations in Europe dealing with delivering education to children with disabilities in elementary and secondary education (irrespective of the further process and if this education takes place in an inclusive or special educational con-

text), the number of initiatives, measures and regulations get scarce when it comes to Higher Education and further diminishes at doctorate level. This leads to a lack of peers (people with severe disabilities) in further (university) research, project work, teaching and last but not least also policy making. It applies to all fields of university research (including disability studies and rehabilitation). What adds quality to state of the art in modern management – implementing diversity – is lost at university.

Method: In preparing for this endeavor and in order to evaluate the situation and possibilities in Austria, we followed a four-fold study path: (a) Preparatory desktop research on legal regulations and numbers at European level, (b) expert interviews with students and researchers (with and without disabilities) asking what keeps candidates from as well as in following a doctorate in Austria, (c) observations from a similar action called PROMI in Germany and (d) setting up a field trial framework in Austria to be able to conduct an accompanying study/work in progress activity for graduates with disabilities in doctorate studies while researching the main facilitators and barriers as well as get a sound understanding on numbers and target group.

Key results: Studies show that the number of masters exiting university is about 8000 per year, about 800 extra finish with a doctorate. An estimated ratio of 20% (people with any form and grade of disability amongst the Austrian population) would mean an output of about 1600 graduated with disability and consequently 160 doctors with disabilities, numbers that are certainly not reached. But also if one only takes 10% of these mere estimations (as in Austria, data on "disability" and health require particular protection and are not part of formal population census), the resulting number – following support and counselling services for students with disabilities at all Austrian Universities – would be overestimated – leading to similar values and findings in other European countries that have a similar "tertiary quota" amongst their labor force.

Conclusion: In parallel to the Austrian field trial – installing and staffing (altogether 6) fully accessible and fully funded 4 year positions for doctoral students with severe disabilities at all major Austrian universities – we will present necessary research to be conducted these next 4 years – compiling a significantly reliable corpus of data/numbers, researching facilitating and detrimental factors (besides financial and accessibility issues – for transferable structures preparing this next level of inclusion: People with Disabili-

ties following a stable research and career path at university, enriching quality of life and research (not only in disability related studies) and bringing high impact research and development to the next, necessary level.

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Accessibility Evaluation of Computer Based Tests

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Background: The accommodations in exams (e.g. scribe, compensatory time and magnification) are widely used for many years to accommodate visually impaired persons (VIPs). Nowadays, most of the exams are conducted using computers and web-based technologies referred to as Computer-based tests (CBTs). These CBTs play an important role in the professional advancement of any individual, starting from university admissions, courses evaluation and grading, to the recruitment in almost all software companies. Barriers in accessing certain components of the CBTs limit the utilization of these technologies for VIPs. In this work, we evaluated the availability and effectiveness of common accommodations in CBTs. To the best of our knowledge, this is the first attempt to systematically study the effectiveness of these accommodations. **Method:** We used a questionnaire to evaluate the accessibility barriers in the CBTs. 24 participants responded until January 15th, 2019. These were VIPs from IIT Kanpur, IIT Delhi and registered participants at the assistive technologies conference, Empower-2018. We analyzed the accessibility of CBT interfaces, the effectiveness of accommodations provided to VIPs, the comparison between available and expected accommodations, and finally the preferences of VIPs for various accommodations. Using this data, we have proposed recommendations to adopt more technology-based accommodations in CBTs. **Key results:** Every VIP is unique and requires appropriate accommodations in CBTs to overcome the accessibility barriers. The data obtained from the survey reveals that 6.9% (2/29) of VIPs preferred scribe over other accommodations. 27.3% (6/22) of those who used a scribe reported enhancement in their performance, rest of them reported either drop or no impact. Hence assistive technologies such as screen readers along with accessible formats of contents should be used to accommodate VIPs. Compensatory time was useful for almost everyone regardless of the extent of disability. The usefulness of magnification was reported by only 25% (3/12) of participants with 90% or more disability, while others reported significant improvement in reading speed. We analyzed the availability and expectation of various accommodations in CBTs and found that scribe and compensatory time were available while accommodations such as magnification of text, screen reader, option for choosing colour contrast and bigger monitor setup were rarely available during CBTs, although data reveals that 30%–50% VIPs preferred these accommodations. **Conclusion:** The results about the effectiveness and preference of using a scribe in CBTs are contrary to the beliefs. Our observations identified the needs for technology-based accommodations over scribe to a diverse group of VIPs. We showed that the extent of residual vision in VIPs is one of the major factor in determining the type of preferred accommodations. CBT interfaces can be personalized to fulfil the needs of VIPs with the use of assistive technologies. In the future, we would like to extend our study for a greater number of people, other disabilities, different types of CBTs and for more geographic locations. Moreover, similar studies can be conducted for the accessibility of online programming competitions.

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LernBAR [Learning based on Augmented Reality] – An inclusive Training Concept for Home Economics

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Background: LernBAR is a research and development project for vocational training using digital technology as a core element. The project examines augmented reality (AR) based vocational learning for people with cognitive impairments in home economics. Digital media can facilitate vocational life and has great potential for challenged learners. One innovative digital learning method is AR-based learning. AR supplies additional information e.g. videos/audio which is presented with

a mobile device (glasses/tablet) in the real environment complementing the view of reality. At the workplace the system can recognize objects or markers to call up environment-related digital artefacts. Learners are supported individually through the learning process, providing motivation, allowing repetitions, etc. AR specifically relates the learning experience to the actual workplace in reality (Fehling 2017, 127ff, 129f). Due to demographic and social development in Germany the importance of home economics increases, however training figures decreased over the years (BiBB Datenreport 2016, 35). A modernization could enhance the appeal and future sustainability of the vocational training (Fehling 2017, 126). The project focuses on realizing AR-based learning and establishing further learning opportunities via an e-learning platform. Therefore, a new curriculum is being developed and tested. Since home economic services constitute a large part of vocational training for people with cognitive impairments the project examines the usability of AR for this target group. Therefore, three institutions that offer vocational training for the target group are supporting the project as partners.

Method: The project starts with analyses of literature and interviews of partners. The curricula for vocational training in home economics are adjusted to include digital learning (like AR). Therefore, the partners' curricula are analysed and merged using document analyses (Mayring 2007, 31). Based on the outcomes of the interviews the learning scenarios are created. Work process analyses are conducted with the partners, including observations, control videos, expert interviews and interviews with trainees (Spöttl and Windelband 2006, 139). The material is used to create learning content. On the technical side an application for displaying the learning content on glasses and tablets is developed and an e-learning platform is adapted for the project. The developed contents are tested with the target group using observations and surveys on acceptance/usability. The results allow target group specific adjustments. Various offers like workshops, guides/manuals, etc. allow the implementation. The project has a duration from June 2018 to May 2021 therefore not all steps have been completed.

Key results: Desired results in practice include 30 learning scenarios for AR and the e-learning platform. Goals in research are to gain practical research data on learning and teaching with digital media/AR and insights on acceptance and usability for people with disabilities.

Conclusion: AR technology is expected to have great impact on future work life (Peddie 2017, 27). The project explores the suitability of AR-based vocational learning for people with cognitive impairments in home economics.

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Mainstream traditional or robotic toys: Which of them better supports playfulness in children with disabilities?

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Background: Play is the main drive for development and is fundamental for physical, cognitive and social development (Piaget, 1945/1972; Vygotsky, 1976). Playfulness is the child's 'disposition to play' (Barnett, 1991). Playfulness can allow to discriminate between play for the sake of play and 'play-like' activities (Visalberghi, 1958), which occur when play is used as a means to achieve 'other' purposes, such as learning or skill improvements.

Children with disabilities can experience limitations and functional problems (intellectual and motor limitations, speech disorders, sensory disturbances, emotional and social difficulties; Tingle, 1990). For these children, play can be limited because of environmental and contextual barriers (Besio, 2017); moreover, play is often used as a means for rehabilitation or educational purposes. Thus, children with disabilities are often prevented from playing for the sake of play. Toys, and specifically robotic toys, can offer interesting solutions to overcome the limitations of play activities and to support Playfulness (Skär, 2002). The project GioDi-1 (2014–2015) showed that robotic toys could support play and playfulness in children with physical impairments (Bulgarelli et al., 2018). The project GioDi-2 (2017–2019) directly compared the impact of similar classical vs robotic toys on the child's playfulness. The current study reports the first results of GioDi-2. The hypothesis was that children would obtain higher Playfulness scores when using robotic toys compared to classic toys.

Method: The sample consisted in 10 children (7 girls, 3 boys; mean age in years = 9.24, SD = 2.51; min = 6.05 years, max = 12.73) with intellectual disabilities; three children had also physical impairments. Data were collected in Fall 2018; each session was video-taped. Children were observed at school, in a separate room, during three sessions, playing with an educator with six different toys: classic and robotic caterpillar, classic and robotic dragon, classic and electronic ball. Fifty-eight sessions were analysed (one child refused to play with the robotic dragon, and one child with the classic caterpillar). Two independent observers coded the Test of Playfulness. Inter-rater agreement had been measured and disagreements had been solved.

Key results: The ToP scores varied from −2.40 to 2.40 (mean score = 0.25, SD = 1.26). No significant differences in the Playfulness scores were observed comparing the use of classic and robotic toys (mean ToP score_classic = 0.29, SD = 1.32; mean ToP score_robotic = 0.20 SD = 1.23, $p > 0.70$). The differences between the Playfulness scores were also analysed for: a) each child: one child only (male, age = 7.75, with intellectual and physical disabilities) obtained a higher Playfulness score when using classic toys than robotic toys; b) each toy: no significant differences were observed (all $p > 0.05$).

Conclusion: First results showed that robotic toys did not support playfulness more than classic toys. Future analyses will deepen the association between the usability and accessibility of the toys and the severity and characteristics of the disabilities. Moreover, the play partners' competence in supporting play and playfulness will be analysed as well.

Keywords: Play, playfulness, robotic toys, intellectual disabilities.

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Meta-analysis on the Impact of Augmented Reality on the Learning Gains of Students with Special Needs

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Background: Augmented Reality (AR) has become an important technology to support learning processes. Many literature reviews have shown the trends, advantages, opportunities, and challenges of this technology in educational settings. These reviews report that one of the most important challenges of AR in education is the limited number of AR applications that consider the special needs of students. However, although there is a claim for the inclusion of accessibility characteristics to address the special needs of users, no study has been conducted to identify the impact of AR on the learning gains of students with special needs. That is, no data show that using this technology benefits the learning process of students with special needs or under what conditions AR should be used to complement their education. Many studies have shown that AR technologies offer unique advantages that enrich the learning environment, advantages that could not be obtained without the help of technology. Consequently, we pose that these unique characteristics of AR have a large impact on special needs education. With the above background, this study proposes to identify the effect size of AR on the learning gains of students with special needs. Additionally, the study analyzes the influence of moderating variables related to the design of the intervention such as learning method, learning environment, and intervention duration

Method: We conducted a meta-analysis to identify the impact of AR on the learning gains of students with special needs. The meta-analysis included 12 empirical studies (N = 270) published between 2010 and 2018 in scientific journals and conference proceedings. In this study, students with special needs refer to students who have some type of disability. Accordingly, we considered four types of disabilities, namely, vision impairment, deaf or hard of hearing, intellectual disabilities, and physical disabilities. The moderating analysis seeks to identify under what conditions students with special needs can obtain the best of this technology for their education.

Key results: The overall effect size of AR on the learning gains of students with special needs was found to be $d = 0.75$, $p < 0.001$. Regarding the moderating variables, the constructivist learning method was found to be the most beneficial for students with special needs ($d = 0.81$, $p < 0.001$). Likewise, AR applications seem to be more effective when interventions are carried out in informal settings outside the classroom ($d = 0.79$, $p < 0.001$). Finally, the results indicate that longitudinal studies were more positive ($d = 0.78$, $p < 0.001$) than cross-sectional studies.

Conclusion: The results indicate that AR has a positive impact on the learning gains of students with spe-

cial needs. The effect size was found to be large for all the subcategories according to Cohen's classification. However, despite the apparent multiple benefits, the use of AR in special needs education is still too limited. Therefore, stakeholders have great opportunities to develop new and better systems that include all type learners.

Keywords: Augmented Reality, Meta-analysis, Special needs education.

Augmenting Reading through Technology: The Living Book Project

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Background: Reading literacy is nowadays a primary skill allowing citizens to 'be' and live in a complex world. The Living Book project aims to address the under-achievement of students in reading and literacy, by developing an innovative approach and related resources with the use of technology to increase students' motivation. The wide range of disabilities and the educational services learners have access to, impact differently on individuals' literacy skills and engagement to literacy activities. Thus, learners with disabilities are considered among the most high-risk groups for low literacy skills. This contribution aims to discuss the theoretical aspects of the Living Book project and the development of the corresponding conceptual framework for teachers' education to support learners with disabilities.

Method: The project aimed at designing and implementing an educators' and other professionals' development program grounded on various interrelated bodies of research, including inclusive education and digital inclusion. The programme was pilot tested during Spring-Fall 2018 with a series of hands-on professional development seminars. To evaluate the applicability and success of the training modules, participants (primary education teachers, special education teachers and librarians) will subsequently undertake a teaching experiment during Fall 2018 – Spring 2019, where they activate Living Book learning paths. Presentation of evaluation and impact findings are out of the scope of this contribution. However, for testing and validating the conceptual framework, teachers' and learners' experiences will be mapped across the framework's blocks.

Key results: In this paper key results refer to the development of a conceptual framework. With respect to (digital) inclusive education the project builds upon the following theoretical perspectives: (i) Augmented reality and innovative technologies; (ii) Universal Design for Learning (iii) the SAMR model for technology integration in Education; (iv) Taxonomies of Assistive Technology and E-Inclusion. For targeting learners with disabilities, the different approaches developed in the project are based on a framework that connects the SAMR model to the UDL principles and Abbot's taxonomy of Assistive Technology for e-inclusion. Often the use of assistive technology in literacy development remains at the level of physical or content/information accessibility. In Living Book, augmented reading for disabled learners is framed in the (re)definition of inclusive education in the digital era. (Assistive) Technology integration is expected to provide accessible but also engaging literacy experiences. Hence innovative technology integration (e.g. the use of AR) elevates from Substitution and Augmentation to Modification and Redefinition of literacy activities. Substitution and Augmentation reflect the UDL representation and action & expression principles, which are aligned to Abbot's Technology for 'Practice' and 'Assist' learning. However, 'Enabling' learning with assistive technology indicates Engagement and thus, calls for Modification and Redefinition of literacy activities. Mapping participants' experiences to the conceptual framework is expected to yield discussions upon the desired shift in the learning paradigm for increasing engagement.

Conclusion: The use of assistive technology in education can go beyond physical access and accessibility. In a digital era, assistive technology is a means to modify and redefine the learning environment for creating digital inclusion opportunities and cultures in schools by problematizing the added value of technology integration in disabled learners' engagement and acknowledging the multi-faced interaction between person, technology and environment.

Keywords: Augmented reading, UDL, SAMR, Augmented reality, Digital inclusion.

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Flipped Classroom for All in Primary Education: Using Technology for Differentiation and Inclusion

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Background: In this article, the results of a multicase study will be presented which aimed to address an important gap in current literature concerning instructional practices using a Flipped Classroom (FC) model, implemented in line with universal design principles. There has been a limited research focus on the implementation of the FC model within the primary education context despite its potential benefits for differentiation and inclusion, especially through the use of technology.

Method: The study is a collaborative action research project, during which the researcher, in collaboration with five primary school teacher participants, explored the effective ways of universal implementation of the FC model in primary school settings in Cyprus. To achieve the aim, this study first developed a pedagogical framework of (Inquiry Based) IB-FC which consists of universal design principles of using the FC model for IBL (Inquiry-Based Learning) at a primary education level. The universal design principles here include the specific pedagogical strategies to motivate and improve students' learning applicable for all primary school subjects, through differentiation and inclusion. The model was implemented for a school year in five different primary schools in Cyprus, engaging 77 students (lower and upper primary). The digital literacy competency of the participant students had been addressed by preparing flips in diverse formats, e.g. video, presentations, games, online readings, webQuests etc. In addition, the flips and the inquiry-based activities in class were uploaded and administered through a Moodle platform (http://protyposxoleio.com), specifically designed for the research. Therefore, all students could access content through any connected device with no compatibility issues. Qualitative data has been selected through classroom investigations and student interviews and has been analysed using NVivo11. The final themes arising were grouped into students' experiences and perceptions.

Key results: Students' experiences and perceptions on the IB-FC implementation have been used to revise the initial instructional tools given to the teachers for developing their lesson designs (e.g. the IB-FC Differentiation tool). This in turn lead to the extraction of seven final universal design principals which could enhance differentiation and inclusion through FC learning, recognizing the critical role of technology in achieving this. These include: *structure and flexibility, simplicity and accessibility, interconnectivity and community, differentiation and personalization, development and progression, motivation and engagement and assessment and evaluation*.

Conclusion: The final IB-FC framework proposed in the findings of this multiple-case study illustrates how the seven universal design principles for FC implementation are connected to the ten instructional IB-FC tools developed: *In-class, orchestration routines, engagement, differentiation, technology, in-flip, community, IB-FC skills, assessment and evaluation, flips and Bring Your Own Device*. These tools mainly highlight the role of technology in freeing up classroom time for more IBL inclusive activities, by enhancing pre-class understanding within the individual learning space through the provision of flips in diverse formats. Hence, the contribution of this study within the AT field focuses on these principles and instructional tools as an attempt to guide FC implementation which addresses the needs of all students, despite their learning type, ability and skills.

Keywords: flipped-learning, differentiation, inclusion, universal design principles.

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Project E-IDEAS: Empowerment of Youth with Intellectual Disabilities Through an Individualized Transition Program Including AT for Acquiring Employment Skills

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Background: The project E-IDEAS is an on-going research funded in 2017 by Marie-Curie Action program and the charity RESPECT. It is implemented at the National University of Ireland in Galway and it is aimed to develop a transition program for allowing persons with Intellectual Disability (ID) to find paid job.

The rational is represented by the high levels of unemployment and underemployment of youths with ID in Ireland.

Considering that youths with ID have less favorable transition outcomes than youths in the general population and that employment opportunities are even less promising the initial question was: *How to bridge the "gap" between what youths with ID "can do" and what they really "are doing" in employment sector?*

Method: The project E-IDEAS uses a mixed method that incorporates participatory research approach with qualitative research methods.

It addresses the current educational and career preparation context for youths with ID in Ireland through a transition program composed by three main activities:

1. Delivery of an Employment Preparation Curriculum (EPCv), developed using a person-centered approach.
2. Provision of an Individualized Internship, supported by job coaches of local organization (EmployAbility Galway) that provides real-life work experience.
3. Use of assistive technology (AT), including tablets and app AVAIL a mobile solution based upon the principles of ABA (Applied Behavior Analysis) enabling learners to develop life skills.

Five persons aged between 20–25 with mild to moderate ID (IQ 50–70) were recruited by a local organization (Ability West). The transition program started in January 2019, it lasts for 4 months and it will be extended until summer 2019.

Key results: The analysis of results is currently ongoing. A questionnaire on the quality of life (San Martin's scale) has been administered to participants at the beginning of the transition program and it will be compared with the data collected at the end of the process. Initial findings already emerged are:

– The provision of EPCv concurrently delivered with the internship reinforces learning and provide a safe environment where to discuss and ask questions.
– The adoption of AT leads to positive results that helps to achieve a long-lasting acquisition of skills to perform job-related tasks although it requires a continuous support.
– A strong partnership between different local stakeholders guarantees an effective transition towards job experiences.

Conclusion: The main practical implication of the research is that through a specific curriculum delivered concurrently with an individualized internship realized in real-work settings, it is possible to empower persons with ID for acquiring employment skills. Also, the adoption of AT reinforces what learned in classroom

as well as tasks' execution during the internship. In this view, the research's results affect the AT field providing the opportunity to develop a technology learning environment that facilitates acquisition and exploration of job-related skills. Future perspective in terms of short and long-term impacts are:

– Improve employability for youth with ID.
– Help service providers in Ireland expand their community services.
– Definition of practical actions aimed at impacting on mind-set and common beliefs with respect to disability and employment.

Keywords: Empowerment, Intellectual Disabilities, Individualized Transition Program, Assistive Technology, Employment Skills

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Special Thematic Session 12
Developing Assistive Technology Together with End-users, Business, Healthcare and Knowledge Institutes – Challenges and Benefits

This thematic session focusses on the potential of living labs in supporting companies in further developing assistive technology in order to develop an effective, usable and sustainable solution of the real problems in health care. What is the benefit of cooperation between companies with AT, knowledge institutes and health care organizations? What is the contribution of research institutes like universities and applied knowledge centers involved? And how do health care institutions themselves organize in order to improve the match between assistive technology developed and needs of in health care.

Chairs: *Katerina Mavrou and Silvio Pagliara*

Designing End-user Adaptable Interactive Rehabilitation Technology
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Background: Technology supported rehabilitation training after stroke has been a topic of interest for many years. While numerous solutions have been developed and evaluated, most of these solutions pertain to a limited set of exercises, pathologies and use cases.

Providing personalized solutions, and adapting to new or changing patient demands, is difficult for such technologies, since most of their functionality has been defined during a design phase that predates their actual use. This calls for technology that facilitates adaptation and customization to patient needs, without demanding skill and knowledge typically associated with designing or implementing new technology.

Method: In close collaboration with a clinical partner, we developed TagTrainer: an end-user adaptable technology for physical rehabilitation after stroke. In an iterative, user-centered process, therapists were involved in the design and implementation of the technology. TagTrainer consists of multiple interactive surfaces that detect objects outfitted with RFID tags, and provides visual and auditory feedback. The system is connected to a computer on which therapists can modify, expand or create exercises for individual patients. Any object of daily life can be integrated into an exercise, simply by attaching an RFID tag to it. TagTrainer was evaluated in four field studies in rehabilitation clinics for a total of 24 weeks. In all studies, we measured technology acceptance (UTAUT), interviewed therapists on their experiences in using TagTrainer, and analyzed the rehabilitation exercises that were created by the therapists.

Key results: Technology acceptance was moderate over the four studies, remaining relatively stable over the course of each study. Therapists created a total of 37 new exercises for their patients, showing that in principle they are able to adapt TagTrainer to the needs of their patients. However, through the interviews we also encountered several issues pertaining to the feasibility of implementing an end-user adaptable technology such as TagTrainer in a clinical context. Amongst others, the organizational model of clinics does not facilitate therapists in engaging in activities other than patient treatment. Additionally, therapists indicated that important efficiency benefits could be reaped from (partly) reusing existing exercises, but that judging the usefulness of exercises created by colleagues for a particular patient prevented them from doing so. Finally, the therapists voiced concerns about the impossibility to validate the effectiveness of each and every personalized exercise.

Conclusion: While the principle of an end-user adaptable technology for physical rehabilitation after stroke seems promising, deploying the technology in a clinical context has shown that there still are many challenges to be overcome. Furthermore, the studies have shown that even when clinical partners are involved in the development of a technology, non-technical and policy issues might arise upon deployment.

'Sharing is Caring': What are the Main Legal and Ethical Challenges to be Looked at when Co-designing Assistive Technologies?

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Background: The way in which assistive technologies (ATs) are ideated and produced today has significantly evolved from the fashion in which they used to be done in the past. Over the recent years, new forms of bottom-up innovation and social collaboration for the co-creation of healthcare solutions have emerged. Such initiatives involve the interaction of a range of stakeholders, including designers, healthcare professionals, makers, fab labs, and end-users who – for different purposes or ideals – put together their efforts and knowledge in order to co-design and reproduce various types of ATs. One notable example of this new paradigm is represented by Careables.org platform – an initiative by the Made4You project. Its aim is to create an online platform to enable stakeholders possessing broad and diverse knowledge to share it for the subsequent co-creation and reproduction of customized healthcare solutions. Examples of ATs created in such a manner include 3D-printable prosthetics hands, wheelchair mounted environment controllers, learning supports, assistive phone cases, open lights for wheelchairs, to mention but a few. While social effects concerning co-designing initiatives clearly appear to be beneficial – especially in cases where a given AT does not exist on the market yet, it is too costly, or it has not been tailored to meet the needs of an individual – the ethical and legal requirements have only been partially addressed in the literature and have rarely been implemented in practice by the aforementioned stakeholders.

Method: Through this contribution we will outline the main legal and ethical requirements to be regarded when a healthcare practitioner, developer or an individual wishes to design, co-create or reproduce an AT through such a bottom-up approach. This contribution stems from a desktop research carried out within the context of the Made4You project by legal researchers of KU Leuven whose main focus was on the EU

primary and secondary legislation dealing with privacy, data protection, intellectual property rights, open source/hardware licensing, and medical devices regulation. Finally, the main ethical principles will be outlined.

Key results: With regard to the legal framework following questions will be addressed: what is the applicable EU legal framework for co-designing ATs and what are the main legal requirements to be considered? The research has shown that as of primarily interest for stakeholders are fundamental human rights (in particular privacy and data protection), intellectual property rights and open source/hardware licensing, liability of ATs co-manufacturers, and qualification of a co-designed AT as a medical device. With regard to the ethical framework the question that has been studied is: what are the major ethical principles to be regarded when co-designing a new AT? Principles such as justice, beneficence, and non-maleficence have been emphasized as the most relevant in such a context.

Conclusion: The findings to be presented through this contribution aim at providing a point of discussion about the legal and ethical aspects for the co-design and co-creation of ATs. The research results are directed towards all stakeholders that may have an interest in undertaking co-designing activities in order to raise awareness of the crucial legal and ethical requirements that should not be overlooked when applying the bottom-up approach for the development of ATs.

Keywords: Intellectual property, open hardware licensing, medical devices.

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Structural Collaboration Between Care Organizations and Universities

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Background: Care technology is regarded as one of the solutions dealing with a growing demand for care. In the Netherlands, care professionals are often contacted by companies marketing their new products. Although long term care organizations are open to new technological developments (e.g. e-health, robots and virtual reality), healthcare professionals dealing with technology implementation in long-term care, face a number of challenges. Firstly, the technology doesn't (always) fit the needs of clients and/or professionals. Secondly, research regarding the added value or feasibility of technological products is scarce; care organizations often lack capabilities and time to evaluate the technology at hand in a proper and concise manner. Lastly, there is lack of structural implementation of care technology within long term care organizations, often resulting in ad-hoc decision making. Seven institutes for long-term care decided to join an initiative started by the Living Lab in Ageing & Long-Term Care (Academische Werkplaats Ouderenzorg Zuid-Limburg, AWO-ZL).

Method: The collaboration named "AWO-ZL Group Care Technology" started in September 2018. Our aim is two-folded:

- Reaching more efficiency for care organizations by:
  * Collaborating in assessing the added value and feasibility of care technology;
  * Sharing experiences and acquired knowledge regarding (test results of) care technology;
  * Involving researchers (supported by bachelor and master students) in life-testing.
- Contributing to the development of care technology products by:
  * Providing feedback to entrepreneurs (on technology in different stages of development) based on their pitches;
  * Organizing and performing life-tests regarding the technological products those entrepreneurs have developed.

Representatives of the seven care organizations, Zuyd University and Maastricht University agreed to meet bimonthly in order to invite technology companies. In these meetings new technologies are discussed even as methods to evaluate them and outcomes of life-tests when available. Each care organization agreed to perform at least one life-test a year, supported by scientific researchers at Zuyd University and Maastricht University. Short interviews were held to capture the experiences of care professionals and entrepreneurs.

Key results: Six meetings have taken place in which 10 companies pitched their technological products; 4 life-tests have been or are planned to be conducted. The first evaluations show positive experiences: care professionals realize they often deal with similar questions: Does the technology work? Do we have (this) need for innovation? Does it fit our patients? Do our

healthcare professionals know how to use the technology at hand? Hence, there's a lot to learn from the experiences and knowledge of other organizations. Entrepreneurs value the positive attitude displayed in the meetings; they feel it is beneficial to meet experts in de field of care technology in order to have thorough discussions. For Zuyd University and Maastricht University the collaboration is a good example of our living lab where practice, research and education intertwine creating a valuable learning environment for all involved (incl. care professionals, researchers and students).

Conclusion: Collaboration between care organizations and universities for evaluating care technology seems beneficial in order to improve implementation of care technology in long-term care organizations.

Keywords: Living Lab, Long-Term Care, Assistive Technology, Technology Implementation.

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Design and Implementation of a Multimodal Wearable System for Functional Assessment in Rehabilitation and Work

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Background: Nowadays, wearable systems offer a not intrusive ecological solution for people monitoring and functional assessment. These platforms represent an ideal tool for evaluating the rehabilitation evolution and job reintegration of people. To control physical and physiological parameters during rehabilitation process, a multi-parametric system is mandatory, but current systems are bulky or not fully integrated. The aim of this project is to develop a modular textile sensing platform fitting different people and job situations.

Method: Co-design mixed with technical analysis is the adopted method. Three design iterations were carried out. In the first step, two Users focus groups participated by patients, caregivers and technologists were carried out for the design of the basic requirements. A dedicated and ad-hoc created, questionnaire web-administered to 40 end-users provided the final definition of the functional requirements of the system. The second step consisted in the technical analysis and design and its validation with a panel of users. Anthropometric analysis and wearability analysis were conducted in parallel with textile materials analysis and technologies selection (for sensing, processing and transmission); according to these outcomes, a preliminary design was developed for aesthetical and comfort assessment only, by simulating hardware shapes and volumes and weight through rapid prototyping techniques. A questionnaire for acceptability and usability based on 5 questions (using Likert scale) confirmed the design.

Key results: According to the results of user research, the main system requirements are: on one side, the need to have a modular wearable system, which guarantees high levels of comfort in terms of breathability, freedom of movement and wearability; on the other side, the system has to guarantee an accurate and dedicated monitoring of the specific rehabilitation activity. In particular, the co-design process highlighted that all users are firstly interested in evaluating the global motor function or even of specific body segments, with comparison of data from the contralateral body districts. Physiological parameters as single-lead electrocardiogram, breathing rate and depth and muscular activity, are relevant in subjects with specific cardiovascular pathologies, e.g. post- strokes, when also a total body motor assessment could be useful to be achieved. According to these outcomes, the wearable system in its full configuration is being developed through the implementation of 13 inertial sensors placed onto the body segments in a network which is integrated with the sensing platform composed of conductive fabric electrodes and a dedicated device for ECG, heart rate frequency and respiratory activity (and also EMG in future configuration).

Conclusion: The Multimodal Wearable system is designed to support monitoring of people during rehabilitation and job reintegration in an ecological setting and in a truly integrated physio-physical approach. The complete development and validation are still ongoing but, the promising results about system accuracy in real situations open new perspective for application of the system in work related pathology prevention and even in sport performance assessment.

Keywords: Wearable System, Multimodal monitoring, Co-Design, Ergonomics, Rehabilitation.

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Making Black Swans Free as a Bird: Freedom, Safety and Courage in Psychogeriatric Care

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Background: Living Labs are public private partnerships that aim to bring innovation closer to practice and, in this study, make innovations more meaningful for healthcare practice. This Living Lab project was conducted in a closed psychogeriatric unit in a healthcare organization in the Netherlands. The facility exists of units with three floors for six psychogeriatric clients on top of each other, which limits the space for clients to move around freely. Dementia patients sometimes have the urge to walk and become restless if free movement is not allowed. This restlessness negatively influences the wellbeing of themselves and the other residents. This project aims to explore possibilities to increase freedom for restless psychogeriatric residents, given the physical constraints of the facility and its location.

Method: The project consisted of two phases. The first phase was an in-depth exploration of the problem without focusing on possible (technological) solutions: interviews ($n = 29$) were conducted with various staff members, and four staff members were shadowed during both day and night shifts. Maximum variation sampling was used to ensure the inclusion of perspectives and experiences of all relevant stakeholders concerning the facility. The data were analyzed using open coding to create a list of themes that were used for the second phase. Secondly, the project group, consisting of researchers and employees of the organization, reflected on the central themes in three sessions following the method of frame innovation to formulate innovative solutions.

Key results: Major emerging themes were freedom versus safety, risk staking, lack of contact with colleagues, high work load and time constraints. Staff reported difficulties moving between the unit floors, and that unrest amongst residents negatively influences their ability to deliver person-centered care. Courage, the willingness to try new possibilities without knowing what the possible outcomes and consequences are, emerged as a necessity to deal with the problems of the facility. Whilst deliberating courage, the insight emerged that only a handful of known residents ('black swans') become restless when their freedom was restricted. If those individuals could be temporarily moved to a different location in the facility, which has a circular hallway, disturbances for all psychogeriatric residents may be avoided. This solution emerged without focusing on technology as a starting point but, according to the participants, it will create a context wherein the use assistive technology has a larger chance of success.

Conclusion: Even though this project did not take assistive technologies as a starting point, the findings of the project are relevant for innovators in technology. All participants came to agree that simply implementing new technologies would not have addressed the problem of the facility. Due to the participatory nature of the research a truly innovative solution was found which, additionally, may increase the chances of success for assistive technologies in reducing restlessness for the residents. From a socio-technical perspective this makes sense: healthcare contexts are systems in which people and technologies are closely interrelated. Only if social and technological innovation go hand in hand, chances of success can be significantly increased.

Keywords: psychogeriatric care, participatory research, socio-technical perspective.

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Stay@home with Dementia: Companies, Healthcare, and Knowledge Institutions Challenged for User-centered Design

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Background: Assisted technology (AT) can support the growing number of patients with dementia and their caregivers in daily life, to improve independence and safety. A mismatch between AT and the needs of persons with dementia might explain the limited use of AT. Pro-active involvement of clients and (informal) caregivers(s) in the design and implementation of AT will maximize implementation and the likelihood of technology acceptance. In this project, AT for patients with dementia were designed based on clients' and

caregivers' needs by bringing companies, healthcare- and knowledge institutions together. The aim of this abstract is to address the design process and experienced difficulties.

Method: Three teams consisting of 5 companies and 7 healthcare institutions were created to design AT. The knowledge institutions coordinated the collaboration. An iterative user-centered design approach was used in which the double diamond model was applied. Firstly, a needs assessment [*Jorina Reekmans, Ryanne Lemmens, Steffi Rijs, Annemie Spooren. Stay@home with dementia: from needs assessment to assistive technology, this volume*] resulted the top-10 problem activities and their barriers which were translated into functional requirements (= discover phase). Secondly, in the define phase, the needs and requirements relevant for the AT being developed were defined. Next, prototypes were developed during an iterative process by companies with input of healthcare professionals, repeatedly checked for the functional requirements and tested multiple times with (informal) caregivers (= develop phase). In the near future, prototypes will be tested with clients. At the end, an AT adapted to the needs of clients will be delivered. Feedback on the process was gathered in an iterative way by observation and informal interviews. At the end, teams were interviewed about their experiences.

Key results: A co-creation session was organized, including different methods encouraging user-centered design, to develop conceptual designs of AT. Based on the problem activities 'using appliances' and 'disorientation', 3 prototypes were developed: 1) a simple and adaptable TV remote with possibilities to link with a relax chair; 2) an AT to stimulate day structure, making use of home automation and video messages for clients; 3) a digital buddy in which informal caregivers receive feedback about the actions of the client. Adaptations were made during the iterative user-centered process based on feedback received during tests with (informal) caregivers. In the first iteration the team members were uncertain about their role and there were some difficulties with communication and collaboration. However, at the end, all stakeholders indicated the added value of the complementary expertise and collaboration. Companies and healthcare institutions indicated they were not used to think out of the box with a focus on the problems and barriers. Knowledge institutions experienced difficulties regarding how to translate user needs into technical requirements and some practical problems (i.e. bringing together the team, recruiting clients to test the prototypes). Results of the final interviews are ongoing.

Conclusion: This study gives an overview an iterative used centered design process for AT for clients with dementia living at home. The conclusive enrichment of the process explains the added value of intensive interdisciplinary collaboration between different stakeholders. However, during this process, difficulties regarding collaboration and practical issues had to be overtaken.

Keywords: assistive technology, dementia, user-centered design, collaboration between companies healthcare organisations knowledge institutions.

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ARTHE: Development of an Upper Limb Active Smart weaRable Orthosis for Stroke THErapy

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Background: Recovering from stroke is a long and intensive process for both patient and therapist. Since the rehabilitation process is limited in time, focus is primarily on regaining lower limb functionality. Non-functional upper limbs are consequently found in 30%–66% of stroke patients, and only 5%–20% show complete recovery. To stimulate the brain motor (re)learning process, therapy should include active participation during repetitive, task-specific and motivational exercises. In this context, the use of assistive robotic devices, complementary to conventional therapy, contributes to enhanced upper limb motor recovery. This abstract presents the development of an upper limb exoskeleton "ARTHE" that enables patients to enhance their exercise routine.

Method: An exoskeleton, assisting stroke patients during intended flexion and extension elbow movements, was developed based on field observation, literature review and co-creation sessions with both therapists and patients. The device uses EMG sensors (biceps and triceps) and a load cell (integrated in the distal part of the exoskeleton) to detect the user's movement intention. Based on these signals the actuation unit provides motor assistance according to exercise and patient specific requirements. An actuation unit capable of delivering 24 Nm continuous torque was selected. To keep the elbow brace lightweight and comfortable, the proposed prototype transfers torque through a Bowden cable system, so the actuator module can be placed on a more stable surface or region (e.g. hip or table). This pro-

totype was tested on 10 healthy subjects and 9 stroke patients, performing therapeutic exercises in a clinical setting (two 30-minute sessions with 1-week interval). Healthy subjects, patients and their therapists ($n = 2$) that participated in the study answered a questionnaire (based on the D-QUEST instrument) related to ease of use, quality of movement and qualitative improvements. Additionally, the interaction forces between therapist and patient were measured during conventional therapy sessions ($n = 8$) to define the minimal necessary motor torque to be applied by the actuation unit.

Key results: All 9 stroke patients reported a desire to practice more with the ARTHE device, while 8 out of 9 found that ARTHE improved their impaired upper limb movement quality. General concerns were the size of the device and usability in a home environment. The original anticipated continuous torque of 24 Nm was found to be too high for use in a therapeutic setting. The measurement of the interaction forces between therapist and stroke patients revealed that an actuation unit with a continuous torque range of 4–5 Nm and a peak torque of 16 Nm is sufficient, reducing the unit significantly in both size and weight. The force sensor proved to be a more reliable sensor for the stroke patient population. It also increases the user-friendliness by eliminating the need for specific sensor placement.

Conclusion: A prototype of an upper limb robotic device was developed. It received positive reactions from patients that tested the device, since they perceived an improvement in their movement quality. However, the device still needs to be downscaled and usability should be further improved. As input signal, force proved to be more user-friendly compared to EMG.

Keywords: Exoskeleton, Upper Limb, Elbow, Stroke, Rehabilitation.

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Combining Forces in Further Developing an Innovation for Incontinence Care

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Background: In the Netherlands 750.000 people have to cope with the consequences of urine incontinence. High expenses of 149 million on a yearly basis are partly due to the fact that often material is changed before saturation levels are reached. On the other hand material is regularly changed late resulting in discomfort for clients and increased care tasks for staff due to changing bed sheets and clothes and washing clients. The IncoSense Smart is an innovation developed by IncoSense bv that aims to contribute to solving inefficiencies and discomfort in incontinent clients. The tool consists of a sensor, a wearable that measures the saturation level of incontinence material, a notification system and a management dashboard. Aim of this study was to assess the impact of the IncoSense Smart at the level of the client, care, and organization in a real life setting.

Method: The study was conducted in a somatic and a psychogeriatric intramural elderly care facility in the Netherlands. Phase 1: the current state of the art and needs with respect to incontinence care were investigated in one focus group session and two individual semi-structured interviews with staff. Phase 2: technical validation within one of the participating care facilities of the IncoSense Smart and investigation its impact. Technical validation was done in a one week test period. The impact of the IncoSense Smart was assessed among 10 somatic, 10 psychogeriatric patients and their caregivers. Data on saturation of the material were collected in week 0, 1, 4 and 10. A focus group with staff and individual interviews with clients completed the study. Outcome measures were: client and staff experiences, saturation of incontinence material when changed, accuracy changes (too early, late, on time), extent to which clients wear material of appropriate size, amount of incontinence material use.

Key results: Seventeen clients completed the study. Average age of clients was 82 years (range: 67–96). People had been living in the care facility for on average for 33 months (range 2–121). Practically, it was not always to possible to detect saturation levels of incontinence material as clients took off the sensors, sensors were thrown away with the material itself by staff, notifications were not sent or received to phones of staff. 446 pieces of incontinence material were weighted in the study period, which contained on average 358 ml of urine. The average saturation level was 40%.

Conclusion: Testing in a real life setting gives essential information for the (further) development of the Incosense Smart. Not every incontinent client in a care facility will benefit equally from the IncoSense Smart, so selection of the appropriate target group requires attention when implementing the system. Size of material used is often too large, an additional advantage of the IncoSense Smart appeared that it makes staff aware

of the need for using the appropriate sizes and applying material correctly. Adaptations were done to the design of the IncoSense Smart in the meantime and the device has been tested in a care facility in Belgium.

Keywords: Incontinence, Elderly Care, Dementia, Sensor technology.

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Special Thematic Session 13
Challenges and Open Issues in Indoor and Outdoor Accessible Mobility

Mobility can be defined as "the ability to move or be moved freely and easily". Despite the advances in ICT, where mobile devices and smart objects (including sensors and internet of things technologies) become even more pervasive and powerful, mobility, and, in particular, accessible mobility is still an issue difficult to address, both in the indoor and outdoor environment. In fact, these two contexts let emerging different structural problems impacting the mobility of people with impairments under different aspects. Just to present some examples: architectural barriers can block the mobility of people with mobility impairments and elderly people, both in the indoor and outdoor spaces; missing accessible information can make hard enjoying a building or a urban path by vision impaired people; people with cognitive disabilities can face difficulty in orienteering due to the difficulty in using the wayfinding systems that can be perceived as complicated and unstructured. The goal of this special thematic session is to create an opportunity to put together experts investigating this topic of interest, and to discuss challenges and open issues in providing accessible mobility, considering both limitations in the current technologies (such as Bluetooth Low Energy technology accuracy for indoor context) and methodologies (such as relying on voluntary crowdsourcing or, on the contrary, on official sources as unique sources of information), and unexplored possibilities (such as innovative low-cost and non-intrusive sensing technologies).

Chairs: *Catia Prandi and Silvia Mirri*

Indoor Navigation for People with Visual Impairment

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Background: People with Visual Impairment (PVI) have limitation in functions of the visual system. It prevents them from seeing, communicating or doing daily activities such as navigation and shopping. So, we have proposed a solution to help them in the shopping process using visual tags. In this solution, we have implemented two applications for identifying PVI location and navigating indoor using QR codes and ArUco markers. We compared both applications to select which marker gives more accuracy and which one can be detected from a long distance.

Method: We have developed two applications. In the first application, QR codes are printed and installed in the environment at regular intervals. Each QR code store information about the current location. Then, an indoor map has been built using a graph to connect among all QR codes. In this graph, nodes represent QR codes while edges are labelled with the direction and the number of steps between nodes connected to them. This map is stored in a database to be used during navigation. When PVI use this application, they give their target location to it using voice commands. Then, it opens the camera to capture photos until a QR code is detected. The position details stored in the detected QR Code is used as an initial location. After that, it calculates the shortest path to the target location based on the stored map. PVI start walking to the appropriate direction using navigation commands. During navigation, PVI try to detect QR codes to identify their current location and receive continuous navigation commands. This process is repeated until they reach their destination point. The second application is the same as the first one, but it uses ArUco marker instead of QR codes. Both of them use camera calibration to make localization more accurate. We compared them to know which one gives more accuracy and which can be detected from a long distance.

Key results: We have tested the developed two applications to measure precision for detecting QR codes and ArUco markers using different distances (1 m, 2 m, 3 m and 4 m). The results show that ArUco markers can be detected from all mentioned ranges while QR codes can be identified from a range up to 1 m. Moreover, ArUco markers can be detected faster than QR codes because PVI do not need to focus the camera in case of ArUco. The results also show that QR codes cannot be identified if the image is blurred. However, ArUco markers give better results as they can be identified if

the image is blurred from a range up to 4 m. The results also show that QR codes and ArUco markers cannot be detected when PVI are moving fast.

Conclusion: We have presented two applications which used a smartphone camera to identify PVI location using visual tags. We have compared both of them, and the results show that ArUco markers are more accurate for indoor navigation than QR codes.

Keywords: Smartphones, Visually impaired, Indoor navigation, Visual tags.

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Understanding Mobility Device Users' Experiences of Discrimination due to Physical Inaccessibility: A Qualitative Study

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Background: By ratifying the United Nations Convention on the Rights of Persons with Disabilities (CRPD), Sweden has undertaken to implement the rights recognized in the Convention. The ability to move around in the community is an important part of enabling participation. According to the CRPD, public buildings and places have to be made accessible for mobility device users. In Sweden, physical inaccessibility is an often-occurring ground for discrimination in notifications to Equality Ombudsman (DO). The overall aim of this study was to generate new knowledge on how mobility device users experience discrimination due to inaccessibility, in what situations, and how they describe their experiences of being discriminated.

Method: Applying a qualitative approach, this cross-sectional study involved perspectives from occupational therapy and design/engineering. In order to understand mobility device users' experiences about inaccessibility and discrimination, a unique material consisting of notifications to DO during 2015–2016 was used. A thematic analysis of 74 notifications focusing on discrimination and use of rollators, wheelchairs (manual/powered), and powered scooters was conducted.

Key results: The analysis resulted in three themes; 1) testing the regulations and hope for a change; 2) being able to be treated and living like people without disabilities; 3) being able to participate and being independent in all environments. The results showed that persons who report discrimination due to physical inaccessibility take support in different laws and regulations, and some notifications revealed requests for compensations. The notifications described how different regulations and conventions serve as basis for persons with disabilities to have access to different physical environments on the same conditions as persons who don't have disabilities. Some notifications showed that persons who report discrimination ask how laws are adhered to. Several notifications described how staff at for example restaurants respond to guests in an undesirable manner, and situations where others do not understand their needs. The notifications described how mobility device users felt discriminated, and disadvantaged due to physical inaccessibility that excludes and makes them unable to live their lives as others and being able to get to places in the same way as others.

Conclusion: Based on mobility device users' own stories in notifications, this study highlights how people experience consequences of inaccessibility as discrimination. The study generates new knowledge on physical inaccessibility as a basis for discrimination. Such knowledge is important to clarify whether current standards sufficiently cater to the use of different types of mobility devices, and a contribution towards enhancing standards and guidelines. In addition, this study contributes with important knowledge on inaccessibility to the ongoing growth of Universal Design.

Keywords: Mobility device, Participation, Inaccessibility, Discrimination, Universal design.

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MEP CROWD: Improving Mobility of Users with Data and Images of High Quality

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Background: Mobile and web technologies allow people to actively participate in the enrichment of maps with accessibility information consisting of reports

and/or images on barriers or points of interest (e.g., Wheelmap, MEP App, mPASS, etc.): maps can display geolocalized pictures of barriers or report information about accessibility of buildings/streets, typically as non-accessible (often represented with a red icon/segment), accessible with some difficulties (yellow), accessible (green). Data collected with the help of users can improve their mobility, but one of the challenges consists in validating the crowd-sensed data, to publish only correct and accurate information.

Method: The proposed solution is based on a crowd-sourcing engine and on a mobile application – called MEP Crowd – that allows users to visualize pictures of barriers reported by other users and answer some questions created by the engine on the declared type of obstacle (e.g., the user is reporting a narrow path), its criticality level (e.g., the user declares that it is not accessible) and about the quality of the pictures; the same questions are distributed to several different users. They are invited to answer some simple questions (e.g., "Does the picture show stairs?"), with "yes", "no", "I don't know". This allows to evaluate both the reliability of the person who uploaded the report, and – by comparing the answers of the single individuals with the answers provided by other users for the same task – to evaluate also the reliability of the evaluator itself.

Users of the MEP CROWD application are engaged with mechanisms based on gamification techniques (e.g., scoring systems, achievements, badges, etc.); a notification system gives feedback to the user about his progress through an established schedule. For questions related to possible explicit content, we apply an image recognition filter that discards those deemed to be harmful a priori; to be compliant with GDPR, the app MEP Crowd is PEGI 16.

Key results: The approach has been applied to over 3500 reports consisting of pictures and forms filled with data about obstacles reported in a survey done with middle school students accompanied by target users, and have been evaluated by people of different age and sex. About 25% of the images and reports were considered unclear: in case of single evaluations on the same barrier, they were discarded; instead, in the cases where more than one report of the same obstacle type exists in the same area, all reports can be merged into a single report characterized by an overall evaluation, which improves the average quality; moreover, images can be ranked and only the images with highest quality are shown to the final users.

Conclusion: MEP Crowd is a system that exploits crowdsourcing quality control techniques in an application that is completely based on people's reports: it identifies and keeps only valid answers, ranks images; evaluates the reliability of both the users providing the reports and the MEP Crowd users themselves.

Keywords: City Accessibility, Crowdsourcing, Mobile solutions.

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On Enhancing Campus Accessibility: Accessible Digital Signage, Wayfinding, and Navigation

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Background: Moving across the urban environment (both outdoor and indoor) could represent a barrier for citizens with disabilities. This is crucial in University Campuses, where students with disabilities must be supported in independently moving across buildings, offices, classrooms, and labs. Even if several laws and acts aim to guarantee buildings accessibility, there is a general lack of tailored and accessible information about buildings structure (including barriers and facilities). In particular, traditional signage reports many limitations in terms of: information, languages, accessibility, and visibility. Digital signage could cover this lack. Moreover, many studies are currently conducted to evaluate positioning technologies and algorithms, providing accessible wayfinding/navigation systems (for instance: NavCog). Our aim is to study and identify a system that integrates these two aspects.

Method: Our main idea is to exploit technologies for indoor positioning and wayfinding/navigation, integrating accessible digital signage, so as to compute personalized paths and routes (avoiding barriers, including facilities), providing accessible interface and interaction (by means of user's mobile devices). We have tested several algorithms and tools and then we have decided to use Beacon technology to identify users' position (according to user's proximity), while smartphone compass has been used to detect users' direction. We mapped the building with a graph, where the beacons correspond to the nodes. Each pair of adjacent beacons has been connected with an arc. Each arc can be marked as accessible, or not, with respect

to a specific disability (e.g., stairs are marked as inaccessible for wheelchair users). Each point of interest (classrooms, labs, restrooms, offices, etc.) has been associated with a beacon. We have designed and developed a prototype of a mobile app, providing two main app usage modalities: (i) reaching a destination within the building, with an accessible path (tailored on the basis of users' needs and preferences); (ii) exploring points of interest in the proximity of user's position. Once a user selects a destination, the prototype computes the shortest personalized path (Dijkstra's algorithm) between the beacon of the starting point (automatically detected) and the beacon of the destination. The path is then visualized and updated whenever a new beacon is sensed. The system has been designed and developed by involving users with disabilities, including them in the development team. The prototype has been designed for all: it provides an accessible interface and interaction for users with visual disabilities and it equipped wheelchairs users with tailored accessible paths within a building. The app prototype has been developed with ReactNative and it has been tested with iOS (with VoiceOver) and Android platforms.

Key results: We have set up an experiment within a historical building of the University of Bologna (Palazzo Riario), as a real case study, and we have involved a group of five students with disabilities (visual and motor/mobility ones), who provided feedback enriching the whole system, appreciating the potentiality of the involved technologies.

Conclusion: The proposed approach can be exploited in different contexts, integrated with outdoor systems, to support users with disabilities while autonomous moving in a campus.

Keywords: Accessible Wayfinding, Accessible Digital Signage, Internet of Things.

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Making Tourism Services Accessible to Visually Impaired Users Through a Mobile App

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Background: Tourism, defined as the practice of traveling for recreation, is not always accessible to all the people. This is particularly true if considering people with visual impairments who often experience difficulties in traveling and enjoying unknown destinations. For these reasons, different volunteers and associations started to provide services to assist visually impaired users while enjoying recreational activities.

With this in mind, we designed and developed a mobile application to aggregate this kind of accessible and trustworthy services and facilitate the meeting between supply and demand, exploiting innovative IT strategies.

We designed the application in collaboration with the Blind Bat association (Forlì, Italy), that deals with the accessibility of cultural and mobility services for the visually impaired users.

Method: The main idea behind this study is to create an accessible mobile application able to provide visually impaired users with a marketplace where to match supply with demand and where providers can meet the consumers' needs. In particular, the main goal is to equip users with an accessible multilingual mobile application where is possible to:

– Set personal preferences related to the graphical user interface (GUI) in term of colors and contrast, font size and family, on the basis of people with low visions and color-blind users' preferences;

– Discoverer touristic/cultural services provided by associations and volunteers, based on:

  * the proximity (exploiting the mobile devices GPS);
  * preferences (exploiting a recommendation system tailored on the basis of the users' needs and preferences, and previously enjoyed services);

– Rate and review enjoyed services, exploiting gamification to motivate users to contribute with feedback.

To design the application, we involved 100 users (49 suffering from low vision and 51 blind users), ranging from 13 to 79 years old, in a questionnaire in order to collect their insights to design such a mobile app. Moreover, we involved 15 users (7 blind users and 8 suffering from low vision) in the evaluation of the accessibility and usability of the app. Findings are presented in the next section.

Key results: The key findings emerged from the questionnaire, considering information about traveling, are:

– the majority of users (28%) travels "more than once a week", the 20% "more than once a year", the 15.5% "once a year", the 14.5% "once a month" (and so on);

– regarding the motivation behind the traveling, most of the users (36.5%) answered tourism and the 20% for visiting family and friends;

– the 86% declared they would like to travel more often, and, the same percentage claimed that having a mobile application will support them in traveling more.

After the developing of the mobile application (both for iPhone and Android OS), 15 users tested the application, to validate its accessibility and the provided functions. One interesting consideration that emerged during the evaluation was related to the sharing feature, considered really relevant for users.

Conclusion: Involving 115 users, we designed, developed, and evaluated a mobile application to facilitate the meeting between supply and demand, exploiting, personalized GUI, recommendation strategies, and gamification.

Keywords: tourism for all, gamification, mobile application, recommendation strategies.

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Shared Control System of Electric Wheelchair for Persons with Severe Disabilities using Reinforcement Learning Method

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Background: Persons with severe disabilities experience difficulties in operating an Electric Wheelchair (EW) mainly due to two reasons. First, some persons with disabilities do not have proper input devices because of their lack of muscle power and the deformation of their hands. Second, even special input devices are developed to meet their physical conditions, there is no guarantee that they can operate the EW correctly as they intend. For the first problem, we have made investigations to understand their physical functions. The structures and parameters of the input devices are then developed based on the quantitatively evaluation of their physical functions. The results show that almost all stages of persons with disabilities can use the novel input devices to give signals with their own operation. However, some of their operation is not accuracy enough to drive an EW especially in some complicated cases such as turning left or right in a narrow corridor even with the special designed input devices. This paper mainly focused on the second problem. Automatic driving wheelchair can partly solve the second problem, however, it is not helpful to maintain their

residual physical functions. Therefore, it is necessary to develop a shared control system which can adjust the control weights between user and machine considering the characteristics of persons with disabilities.

Method: Based on the results of the previous research, after analyzing their operating characteristics, a shared control system using reinforcement learning method is proposed in this paper to adjust the control weight between user and machine to meet the requirement that making full use of usersą́ŕ operating abilities and giving assistance when necessary. The reward for reinforcement learning is designed considering usersą́ŕ operating burden, safety and comfort. The structure and the parameters of the reinforcement learning algorithms can also be designed to meet the different requirements from users such as less training times and the way the machine side intervenes.

Key results: Because the straight and yaw are two fundamental movements for EW driving, three courses including going straight in a corridor, stopping before an obstacle and turning left, are used in the simulation to verify the effectiveness of the method. According to the user's operating characteristics, two different situations are considered: users' turning signal is insufficient or users' turning signal is oversteered. The simulation results show that the proposed shared control system can gradually adjust the control weights between the user and machine, making the movement of the EW safe and comfortable while ensuring making full use of userą́fs control signals. The entire convergence process is basically within ten trails.

Conclusion: A novel shared control system using reinforcement learning method is proposed to adjust the control weights between user and machine considering the characteristics of persons with disabilities. After several trails, the weights between users and machine can be adjusted to make full use of users' operating abilities and also make the movement of the EW safe and comfortable.

Keywords: Shared control, Electric wheelchair, Severe disabilities, Reinforcement learning

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The Effect of Footway Crossfall Gradient on one arm and leg drive wheelchairs

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Background: The footway crossfall gradient is a big barrier for wheelchair users. In Japan, the Law for Promoting Barrier-free Transport and Facilities for the Elderly and the Disabled and its guideline indicate that the footway crossfall gradient should be recommended to be 1% or less and it might be allowed to be no greater than 2% when it is unavoidable. However, many footway crossfall gradients above the standard remain.

Many people with stroke require manual wheelchairs for mobility. They propel wheelchairs with both the sound arm and leg. It is necessary to clarify the evidence for these guidelines how changes in a crossfall gradient affect the accessibility and the physical load of one arm and leg drive wheelchair users. And the objective assessment of barrier-free road construction to improve the accessibility of a wheelchair should be investigated. The purpose of study is to clarify the effect of footway crossfall gradient on one arm and leg drive wheelchairs by the wheelchair propelling force.

Method: The dynamic wheelchair propelling force was measured by using a torque meter equipped on a wheelchair (Kyowa Electronic Instruments) to analyze the required force when propelling on the footway crossfall. I experimented two kinds of gradients of 0.4% and 4% in actual footway.

In this study, I measured the physical load of 4% gradient because many footway crossfall gradient above the standard and compared it of 4% gradient and flat gradient. Subjects were five healthy persons simulating hemiplegia. They propelled wheelchairs with both one arm and leg for 30 meters. In addition, I measured how much the wheelchair deviated from a center line. The torque propelling force was measured when subjects propelled the hand rim at upslope and downslope side.

Key results: When subjects propelled wheelchair using an arm and a leg at the downslope side, the workload of the 4% gradient was significantly larger than the 0.4% gradient. On the other hand, at the upslope side, there was no significant difference in workload. However, in the 4% gradient, two subjects moved down the slope up to 40 cm from center line when they propelled wheelchair using an arm and a leg at the upslope side, and they applied a great deal of force in the opposite direction to apply the brakes. When wheelchair users propel an arm and a leg, it is thought that a greater force is applied to the leg than the arm.

Conclusion: Previous research has shown that there is a difference of force between the upslope and downslope sides of a two-hand drive wheelchair. Similarly, in this study, this difference of force can be achieved by applying a braking force to the upslope side of the wheelchair, and an increase in force on the downslope side. However, some subjects were unable to keep the wheelchair straight line against the force by the crossfall, it was found that the crossfll gradient was a significant barrier for wheelchair user with single arm and leg.

Keywords: Manual Wheelchair, Cross Slope, Physical Load, hemiplegia.

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Special Thematic Session 14
Pathological Speech Processing for Healthcare and Wellbeing

There are an increasing number of people with debilitating speech pathologies (e.g., due to stroke, Parkinson's, etc.). These groups face communication problems that can lead to social exclusion. They are now being further marginalised by a new wave of speech technology that is increasingly woven into everyday life but which is not robust to atypical speech. This thematic session will present research on the use of audio and speech processing for healthcare and wellbeing. In particular, we welcome papers on detecting, treating and living with pathological speech and associated conditions. It will bring together researchers from the fields of speech and language processing, medicine, psychology, as well as disciplines related health and aging and thus will contribute to the advancement of cross-disciplinary speech and language research.

Chairs: *Heidi Christensen*

Global Challenges in Pathological Speech Technology

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Picking up on the theme of AAATE19, I present a critical review of research and achievements in developing speech technology for people whose speech is abnormal. I will concentrate on what I know: how things have developed at the University of Sheffield, where this topic has been active for over 20 years. There have been notable successes: we have shown that

– It is possible to obtain good recognition results for people with severe dysarthria with very simple statistical models if you can train for each individual speaker.

– Speakers can improve their articulation given visual feedback based on the closeness of what they say to their best attempt so far.

– That such feedback can be used as the basis for speech training aids, where the therapist devises exercises for individual clients.

– That tailored speech recognition can be used as the basis for a communication aid by using recognition results to drive a synthesiser that 'speaks' in a normal voice.

– That the models used in statistical speech synthesis can be adapted to produce a normal voice which captures the characteristics of a client with disordered speech.

– That it is possible to restore the individual voice of someone who can no longer speak at all by a learned transformation from articulatory sensor data to acoustics.

However, the impact of this work has been limited. It tends to produce good demonstrations, papers and Ph.Ds but there is little which is deployed in real clinical applications. I will discuss why this is so and conclude with suggestions about how the community might work together to improve matters. In particular,

– A common problem is in finding enough data for machine learning. We need to automatically collect data from systems which are already in use and, as far as possible, to share this data.

– We need to work towards systems which adapt to their users, rather than insisting that the users adapt to them.

Keywords: speech technology, disordered speech, impact.

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Acoustic Features to Support the Perceptual Evaluation of Accent Production in Dysarthric Speech

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Background: Prosodic disorders are reported in a significant number of clinical conditions and have a negative impact on speech intelligibility and comprehensibility. Research on acoustic features of prosody in pathological speech is rather scarce. Previous studies on sentence accent production correlate this prosodic function with movements of the fundamental frequency (F0), intensity and duration. However, it is unclear how differences between accented and non-accented syllables are objectively expressed and how these changes in F0, intensity, and duration are related with the sentence, and with the preceding segment of the accent location. The goals of this research are to identify relevant acoustic features of sentence accent production in Dutch, including derived features of F0, intensity, and duration, allowing the classification between accented or unaccented syllables in an accent production task and to objectively demonstrate the similarities and differences between healthy and speakers with dysarthria in sentence accent production.
Method: Persons affected with dysarthria are the principal population in this study because in healthy speech the strategies for accent production are more consistent, 80 adult speakers (30 healthy and 50 with speech impairment) were asked to produce 3 pairs of sentences with different accent positions. Three experts performed perceptual judgments of the samples. An acoustic analysis of all speech samples was performed, a set of 20 features was generated for each sentence and was divided into three different groups, resulting in feature sets related to frequency, intensity, and duration within the target syllable, in contrast with the previous syllable and also in contrast with the entire sentence. These features were used as input for a Linear Discriminant Analysis. A statistical analysis was performed (two-sample Kolmogorov-Smirnov test), aiming to find potential differences in the accentuation process of speakers with and without dysarthria.
Key results: Outcomes of the analysis show the relevant acoustic features used to detect accented and

unaccented syllables and reveal that healthy speakers mainly rely on the following features to produce a perceptually detectable accent: a change in frequency within the target syllable with simultaneous increase of intensity and contrast in frequency between the target syllable and the previous syllable. Speakers with dysarthria mainly use the contrast in frequency and intensity between the target syllable and the previous syllable rather than the contrast with the rest of the sentence. They also use durational parameters as an element in prosodic accent production. Although in both groups some common features are used, they differ significantly ($p < 0.01$) in the accent production. The latter was established by means of newly developed acoustic features.

Conclusion: The results of this study provided a limited set of acoustic features to characterize sentence accent in a reliable way. This research allows a better understanding of accent production and the different strategies used by healthy and speakers with dysarthria. It also opens an opportunity for the development of an objective and automatic tool to evaluate contrastive stress tasks. This study could be inspiring for speech-language pathologists looking for compensatory strategies in patients with speech disorders and more appropriate therapy methods.

Keywords: Sentence accent, Dysarthria, Acoustic features, Prosody.

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Enabling Early Detection and Continuous Monitoring of Parkinson's Disease

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Background: Parkinson's disease (PD) currently affects 6.3 million people worldwide, and with an aging European population, this number is set to rise. People with this incurable disease suffer from weakness, tremor, and rigidity. Biomarkers of the disease have yet to be fully investigated, and so expensive and time-consuming clinical assessments are required but all too often never carried out. Early detection of the disease and continuous monitoring of its progression can greatly aid in the application of therapies to delay further symptoms and help patients and family manage it both mentally and physically. As symptoms of PD manifest in the voice, we are working towards automatic recognition and monitoring of Parkinson's disease directly from the voice. Through embedded sensors, PD tests can be carried out at ultra-low-cost, are highly scalable, do not require a visit to a clinic, and can generate high-frequency monitoring data. Our study focuses on differentiating between healthy and diseased individuals, and predicting the severity of a patient's disease.

Method: Using openSMILE, our large space feature extraction toolkit, we analysed audio samples collected from a clinical trial featuring 20 patients in various stages of the disease along with a control group of 30 subjects of the same age range. We were also provided with UPDRS Scores which denote the severity of each patient's condition on a scale from 0–199 (worst). The audio samples contain extended vowel utterances "aah", successive consonant-vowel utterances "pa-ta-ka", read speech, and free speech. Several thousand direct and derived audio features were evaluated w.r.t. their correlation with the test subjects. Support vector machine (SVM) classification models were used to differentiate between patients and healthy subjects, and linear regression models were implemented to predict the patients' severity of the disease. For this part of the study, only the extended vowel and successive consonant-vowel utterances were utilized.

Key results: Several audio features have been shown to correlate well with our binary classification tasks. In the case of extended vowel utterances, features which showed strong correlation were MFCC coefficients, Jitter, F0 and Harmonic-to-noise ratio. In particular, F0 variations and discontinuities proved to be the most useful. Our algorithms were able to provide a clean separation between healthy subjects and patients with PD, with an average unweighted accuracy of 91% on subject independent folds using a combination of consonant-vowel and vowel sounds. In addition, the UPDRS scores were predicted with a Pearson correlation of 0.55 using only the successive consonant-vowel sounds.

Conclusion: We have successfully integrated the openSMILE technology in low-resource embedded systems like smartphones, but more importantly, in low-energy wearable sensors such as smartwatches. This is crucial since it enables the continuous monitoring of a patient's condition through a minimally invasive device placed on the patient themselves. This de-

vice would monitor the patient's normal speech in everyday life. More accurate measurements could be frequently obtained through structured voice tests (such as extended vowel utterances), performed on a smartphone by any health care assistant.

Keywords: openSMILE, Parkinson's disease, wearable sensors.

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Apkinson: a Mobile Solution for Multimodal Assessment of Patients with Parkinson's Disease

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Background: Parkinson's disease is a neurological disorder that produces motor impairments in the patients, including bradykinesia, resting tremor, and different speech impairments. The motor symptoms progress differently among patients, thus it is important to monitor their symptoms individually and continuously. The continuous monitoring is not always possible for many patients, especially those with low accessibility to healthcare services. There is a need for a system to track the disease progression of the patients individually. A smartphone application that combines speech and movement analysis could be a suitable mechanism to monitor the disease progression. Such application will be beneficial for patients and caregivers to be informed about the current stage of the disease; and for clinicians to make timely decisions regarding the medication and therapy of the patients. Various applications have been developed to monitor Parkinson's patients. However, most of them only evaluate the upper and lower limbs symptoms using the inertial sensors from the smartphone. There are no applications to perform a robust analysis of the speech state of the patients. On the other hand, related studies have shown that it is possible to evaluate the speech impairments of Parkinson's patients using signals captured with the smartphones. However, such studies only consider the smartphone to record the speech data, without providing a feedback mechanism to the patient about the current state of the disease.

Method: We introduced a new application called Apkinson to evaluate continuously the speech and movement symptoms of Parkinson's patients, providing a feedback mechanism about the current stage of the disease. The patients are asked to do different speech and movement exercises every day, which are selected from an exercise bank that contains a total of 35 exercises. The speech exercises include the phonation of sustained vowels, diadochokinetic utterances, several sentences that the patient has to read, and the description of images that appear in the screen. On the other hand, movement exercises are captured using the inertial sensors of the smartphone to evaluate symptoms in the upper and lower limbs, such as postural tremor, kinetic tremor, finger tapping, gait deficits, among others. At the end of the exercise session, Apkinson evaluates the performance of the patient, while it keeps a register of the results from previous sessions. This analysis will allow the assessment of the progress of the disease of the patients.

Key results: At the moment, a group of 20 patients is testing the functionalities of Apkinson. They performed all the speech and movement exercises and received the proper feedback about their performance. The speech state is evaluated in terms of phonation, articulation, and prosody, while the assessment of movement deficits is evaluated according to the tremor amplitude and the stability of the movements.

Conclusion: We introduced Apkinson, a new smartphone application designed to capture speech and movement signals using the patient's smartphones when they perform different exercises. The patients receive feedback about their performance after doing the exercises. Further releases of Apkinson will include robust models to predict the neurological state of the patients.

Keywords: Parkinson's disease, Mobile application, Speech assessment, Motor assessment.

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Generating Phonological Feedback for Evidence-based Speech Therapy

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Background: The number of people with debilitating speech pathologies due to stroke, Parkinson's or other age-related diseases, is ever-increasing. Tools

to remedy the communication problems or otherwise support the patients thus have high social value. The main points of attention for support are: detection, therapy and assisted living. Our research focuses on speech therapy, specifically on improving the ASISTO e-health tool for training and evaluating pathological speakers. Below, we briefly list the main properties of the existing tool and possibilities to make the e-therapy tool more accessible, more engaging, and more individually targeted. The current tool is designed for Dutch speakers. Expanding to multiple languages will significantly extend the population that benefits from the tool. The current version covers a limited set of pathologies, such as dysarthria and Laryngectomy. A more versatile and robust model can be obtained by learning commonalities across different pathologies. Providing detailed feedback, rather than intelligibility, based on phonological features is expected to make the e-therapy more effective.

Method: Having access to more data in multiple languages is a vital part of the solution to achieve the aforementioned objectives. To collect and aggregate the data, we collaborate with clinical institutes (UMC-Utrecht, NKI-Amsterdam) and the industrial sector (EML-European Media Laboratory). 54,231 speakers from ASISTO and COPAS database are used, with recordings of 1 minute/speaker and the target label quality as follows:

	Good	Average	Bad
ASISTO	65.45%	23.64%	10.91%
COPAS	89.61%	6.93%	3.46%

Key results: Pathological data is very diverse and sparse in nature. Handling the more diverse and larger data-sets requires efficient and flexible training procedures to extract the phonological features from the audio. Switching from a Multi-Layer Perceptron (MLP) implemented in C to Pytorch was a first step to achieve the desired speedup and flexibility. As a result, training time is now reduced with a factor of 20 without loss in performance. To further improve the model, we focus on: *Robustness:* Robust machine learning paradigms on unseen data (e.g., Dropout, mini batch normalization, weight decay) will be adopted. To combat overfitting even further, we aim for compact models that incorporate constraints base on physiology. *Exploiting commonalities across pathologies/languages:* Despite the differences in pathologies and exercise type, we expect that modified training algorithms could lead to a single overarching and multipronged model. Ex-

ploiting cross-language commonalities is due to the use of phonological features straightforward. *Detailed feedback based on phonological features:* Phonological features provide extra support to the therapists in diagnosing the main problems, tracking the progress of the patient and the efficacity of the exercises (evidence-based therapy). Patients benefit as well from more informative feedback.

Conclusion: Learning commonalities across pathologies and across languages should make the ASISTO tool more versatile and more robust. Also employing phonological features provides a rich analysis of the speech which is expected to benefit both the speech therapists and the patient, hence making the e-therapy tool more effective.

Keywords: TAPAS, ASISTO, Pathological speech processing, e-Therapy, Phonological feedback.

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From VIVOCA to VocaTempo: development and evaluation of a voice-input voice-output communication aid app

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Background: People with severe physical disabilities often have difficulty accessing communication aids via commonly available access methods. An alternative approach, using dysarthric speech recognition as an access method, was described at the AAATE conference in 2007. The voice-input voice-output communication aid (VIVOCA) was not developed for the commercial market at the time, partly due to the limitations of available hardware. Subsequent widespread availability of tablet computers led to the further development of the VIVOCA concept, and a commercially available product, VocaTempo, has been released as a tablet-based app aimed at children and young people. This paper describes the development and evaluation of VocaTempo.

Methods: A two-stage collaborative R&D project involving a public-sector AT provider, a university research centre and company developing speech therapy and communication apps, took place over 18-months. Iterative design, development and evaluation resulted

in an app, which uses the (dysarthric) speech of individual users as an access method to produce clear synthetic speech output phrases. Two evaluation phases were carried out; the first was a proof of concept evaluation, to assess performance, usability and acceptability within a controlled environment, and to identify key user requirements. The second was a 'real life' evaluation, to the assess performance, usability and acceptability, of an updated app (based on phase 1 findings), in everyday usage environments, and to evaluate its potential impact, including how VocaTempo may be incorporated into usersʼ communication strategies. The evaluations used a mix of qualitative (observation, interviews with users and therapists) and quantitative (task completion, communication speed) methods.

Results: The VIVOCA concept and speech recognition technology were successfully incorporated into a professionally produced tablet-based app.

First evaluation: Five individuals aged 19–22 years trialled VocaTempo. The app was shown to be highly usable, reliable and easy to learn to use. For 4 out of 5 participants, the app was faster than their current communication method. Average speech recognition rate was 94%, ranging from 87.5% to 100%. The appʼs rejection of vocalisations due to mis-timing of vocalisations and background noise were issues which needed addressing. All participants found the app to be acceptable and most wanted to continue to use the app in the future. A range of requirements for further development of the app were identified.

Second evaluation: Eleven individuals aged 5–21 years trialled the re-developed app. The app recognised 75–100% of vocalisations in controlled conditions, and recognition increased with use. Participants responded positively to the concept of the app and gave positive feedback to the set up procedure. Qualitative data suggests the app was suitable for use in real life situations, and provided examples of how users may utilise the app for different purposes and in different scenarios. We identified some feature and bug issues and developed practice recommendations on mounting, access, use of external microphones, and user support.

Conclusion: The development of the VIVOCA concept has resulted in a tablet-based app that successfully uses speech recognition as a communication aid access method. The app, VocaTempo, has potential benefits for a variety of children and young people.

Keywords: Communication aid, speech recognition.

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Special Thematic Session 15
Robotics and Virtual Worlds for wheelchair users – from ideas to reality: Innovation, Training, and Roadmap to Market (The ADAPT project)

Assistive Technologies (AT) in the form of Socially Assistive Robotics (SARs) and smart Electric Powered Wheelchairs (EPWs) can be effective tools to empower people with mobility disabilities and improve social interactions, independence and autonomy in everyday life, leading to positive emotional wellbeing. However, driving an EPW safely can be challenging due to range of barriers and this leads to AT abandonment and social isolation. Existing barriers in the uptake of AT solutions for EPW users include interdisciplinary communication, standardization of technology, interoperability, limited involvement of users, lack of AT training for healthcare professionals, and synergies between researchers and markets.

In this Special Thematic Session, we will present papers linked to a European collaborative project 'Assistive Devices for empowering disAbled People through robotic Technologies' (ADAPT). The ADAPT project aims to tackle the above mentioned challenges in three ways. First, the project is adapting existing technology, and creating new innovative assistive technologies based on advances in robotics, namely an intelligent connected wheelchair equipped with Driving Assistance (DA) technologies and a wheelchair driving simulator based on Virtual Reality (VR), for the purpose of testing smart wheelchairs and training/rehabilitating users. Second, the project is filling the gap in the current healthcare workforce development and training by developing training materials and sessions to engage more efficiently the healthcare professionals with the use of AT solutions. Third, the ADAPT partnership is developing a roadmap of relevant stakeholders and market events to promote the results of the project and ensure the sustainability of the technology developed. The partnership involves fifteen organisations in UK and France, including Health Trusts, Universities and AT companies, with teams of engineers, healthcare professionals and clinical scientists who are collaborating to build interdisciplinary networks and approaches to AT technology development, healthcare professional AT training, and transfer of knowledge to markets. The project is funded by Interreg VA France (Channel) England Programme and runs for 4 years (2017–2020).

The papers presented in this session will discuss project progress in the respective areas of AT and so-

cially assistive robotics for wheelchair users, AT training and professional development, and sustainability of AT solutions in the health and social care sector.
Chair: *Eleni Hatzidimitriadou*

ADAPT: An EU Multidisciplinary Project in Robotics Rehabilitation for Empowering People with Disabilities

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Background: Ageing societies and the increase in chronic disabilities are irrevocable trends in the EU. Many people with complex disabilities face increased isolation due to a loss of independent mobility. Several studies highlight the key role of innovative Assistive Technologies and "smart" Electrical Powered Wheelchair as effective tools to empower disabled people and improve their social inclusion. Nevertheless, standardization, interoperability, limited involvement of users, lack of specialist training for health professionals impede the uptake of such innovations. The purpose of this presentation is to give an overview of the European INTERREG VA FCE ADAPT project "Assistive Devices for empowering disAbled People through robotic Technologies"[1] which aims to develop, promote the undertaking of innovative assistive technologies based on Robotics and Information & Communication Technologies for the benefit of disabled people.

Method: A transdisciplinary consortium of French and English partners formed the 4-year ADAPT project, starting in May 2017. The project aims to overcome the barriers to the uptake of assistive technology by developing:

- Driving assistance technologies integrated into a powered wheelchair to compensate for user disabilities and to monitor and report changes in users' health
- A virtual reality powered wheelchair simulator platform to give to the user an immersive experience of driving a smart EPW. Professionals will assess

the suitability of the EPW for particular patients and environments and gain understanding from the user perspective.
- Developing innovative assistive technologies training programs to fill the current gap in the healthcare training programs about digital innovative technologies in the field of health and disability
- Formalizing agreements between research institutions and companies to facilitate the uptake of the ADAPT's results by the market.

Key results: An overview of the ADAPT preliminary results will be presented. A specific focus will be pointed out on:

- The virtual reality driving simulator system for which a preliminary study has been conducted with volunteers to evaluate the benefice of the motion platform regarding the kinestosis issues;
- The driving assistance systems integrated on the powered wheelchair for which tests have been conducted in labs;
- The first units of training programs created for the healthcare professionals;
- The first activities carried out in order to make the uptake of the ADAPT's results easier by the market

Conclusion: The talk will give an overview of the ADAPT project: context, challenges, methodology of work and preliminary results. This presentation will also highlight the next stages of the project regarding the development and tests of the technological systems, the next training programs to be developed and the actions undertaken to favor the spreading to the ADAPT results to the market.

Keywords: Assistive technologies, Robotics, Virtual reality, Training, Market accessibility.

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Artificial Intelligence for Safe Assisted Driving Based on User Head Movements in Robotic Wheelchairs

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Background: Wheelchair users do not always have the ability to control a powered wheelchair using a

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normal joystick due to factors that restrict the use of their arms and hands. For a certain number of these individuals, which still retain mobility of their head, alternative methods have been devised, such as chin-joysticks, head switches, or, sip-and-puff control. Such solutions can be bulky, cumbersome, unintuitive, or, simply uncomfortable and taxing for the user. This work presents an alternative head-based drive-control system for wheelchair users.

Method: Using recent advancements in the field of deep-learning networks, we have developed a drive-control solution based on two popular neural network models, which make use of a low-cost RGB camera to track the user's head and estimate its position and orientation. Head movements are translated to drive commands by which a user is able to control the speed and direction of the wheelchair. This control system works on top of our collision avoidance algorithm which adds an extra level of safety and prevents movements that could occur from any misinterpreted input. Head-tracking is achieved in two stages. The first stage uses the popular YOLO deep-learning object detection algorithm which we have re-trained specifically for face detection. The second stage uses a residual neural network (ResNet), re-trained specifically for estimating head pose. The YOLO network detects the user's face from the camera stream in real time, which is then extracted from the image. The face detected is subsequently passed to the ResNet neural network, which outputs an estimation of the yaw and pitch of the head. These two outputs are translated into drive commands, forward-backward for pitch, and left-right for yaw. The system runs under the ROS (Robot Operating System) framework, and all processing is achieved using a Jetson TX2 board, an embedded AI computing device with a CUDA enabled NViDIA GPU which is powered from the wheelchair batteries.

Key results: Trials with twenty participants (not disabled) were conducted in a simulated environment with a joystick in-the-loop setup as baseline for evaluation, and an RGB camera for head-tracking. Two setups were tested: with, and without collision avoidance. With the exception of three expert users of the head-tracking system, who completed the course without collisions, first-time users did not successfully pass the course. With the collision avoidance system, all participants completed the course without collisions, both using head-tracking and joystick. Average time to completion using head-tracking was 70.16% ($\pm$ 25.78%) higher than using the standard joystick without collision avoidance. When driving with the

standard joystick, the collision avoidance system introduces an average 22.75% ($\pm$ 14.56%) increase in completion time.

Conclusion: Our system demonstrates the practicality of using innovative deep-learning artificial intelligence coupled with a collision avoidance system for head-controlled driving of powered wheelchairs. This approach could prove preferable to currently available solutions because of its simplicity and efficiency. Additionally, input from the head-tracking system could be redirected, in order to control a tablet or smartphone, or send commands to a smart home or other Internet of Things (IoT) devices.

Keywords: Artificial Intelligence, Robotic wheelchair, Head-tracking.

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A Simulator to Promote the Return to Work of Wheelchair Users

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Background: Return to work and participation in the community life have been recognized to improve wheelchair users (WUs) quality of life. Therefore, the development of strategies to help them recover their autonomy in the activities of daily living (ADL) represents a key challenge. Virtual Reality (VR) has recently emerged as a promising tool for providing end users with a multi-sensory simulation of diverse scenarios, in an interactive, controllable, repeatable and safe environment, increasing the possibility to acquire new skills. In this work, a VR-based simulator aimed at promoting the work reintegration for WUs has been designed and developed.

Method: The needs of WUs, as well as the characteristics of current clinical practice in standard care, have been investigated to define the requirements of the VR-based wheelchair simulator. Three different scenarios

have been identified to properly address mobility and ADL-related issues: (1) driving the wheelchair in an outdoor environment, and moving around and accomplish specific tasks (2) in the house and (3) at the workplace.

Key results: Up to now, only the outdoor environment has been developed. It specifically addresses users' mobility limitations, thus it requires the WU to overcome different barriers, such as ramps or steps, and to avoid moving obstacles, i.e. pawns and cars. The first prototype has been deployed to run on the GRAIL platform (Gait Real-time Analysis Interactive Lab). An appropriate seat – to be anchored on the GRAIL treadmill, together with the two wheelchair's rear wheels – has been designed in order to fit different anatomical features and thus to be usable by as many users as possible. Specific modules were developed using GRAIL commercial software (D-Flow) to handle user's navigation in the virtual scene, which is rendered in real-time by using OGRE rendering engine.

The currently-developed application allows the simulation of both electronic and manual wheelchair; in the former case, the user will have the chance of using a joystick, controlled either with the hand or the chin. In the latter, markers placed on the wheelchair's wheels are used to determine the direction and the velocity of the user's motion.

Future Works: The deployed virtual environment will be validated in the next months enrolling both un-experienced ($n = 10$) and experienced users ($n = 10$, WST-Q > 80). Data regarding the whole users' experience will be collected and analyzed to assess the system usability and acceptance, and thus the feasibility of a training program exploiting VR dedicated to WUs. The other two scenarios (i.e. house and workplace-contextualized training) will be developed and validated as well. The final step foreseen in the project is the development of a platform independent from the GRAIL. New functionalities will be implemented using Unity 3D as game engine to allow the navigation in the scenes using a Head Mounted Display: this should increase users' immersion and engagement. The GRAIL treadmill will also be replaced with a Steward platform, plus two motors acting on the wheelchair's wheels, for the correct perception of vestibular and haptic feedbacks.

Keywords: wheelchair user, virtual reality, training.

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A Literature Review of the Challenges Encountered in the Adoption of Assistive Technology (AT) and Training of Healthcare Professionals

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Background: Long-term disabilities often result in loss of autonomy and social interaction. Accordingly, there is a demand for Assistive Technology (AT) devices to enable individuals to live independently for as long as possible. However, many people experience difficulties in obtaining and using AT. This paper presents findings from a narrative literature review undertaken as part of the development of AT training for healthcare professionals, one of the work areas of the ADAPT project (Assistive Devices for Empowering Disabled People through Robotic Technologies), funded by EU INTERREG France (Channel) England. The results of the review informed the design of a survey of healthcare professionals regarding their views and experiences of AT and the development of AT training.

Method: The review sought to understand challenges encountered in the adoption and use of AT as well as how training of healthcare professionals in AT takes place. A narrative approach was adopted as the most appropriate way to synthesise published literature on this topic and describe its current state-of-art. Narrative reviews are considered an important educational tool in continuing professional development. An initial search was conducted via databases in the UK and France, including CINAHL, Academic Search Index, Social Sciences Citation Index, BDSP (Base de données en Santé Publique), Documentation EHESP/MSSH (Ecole des Hautes Etudes en Santé Publique/Maison des Sciences Sociales et Handicap), Cairn, Google Scholar and Pubmed. Inclusion criteria for the review included: covering issues relating to AT provision and training, English or French language, and published from 1990 onwards. Application of these criteria elicited 79 sources, including journal papers (48), reports (11), online sources (11), books (6) and conference papers (3). Sources were thematically analysed to draw out key themes.

Key results: The majority of papers were from USA and Canada (27), then UK (20) and France (19). Others were from Europe (7), Australia (3), country unknown (2), and one joint UK/France publication. The main source of literature was journal papers (48), of which the most common types were practice reports (18), evaluation surveys (10) and qualitative studies (9). The review uncovered a number of key challenges related to the adoption of devices, including: difficulty defining AT across disciplines, lack of knowledge of healthcare professionals and users, obtrusiveness and stigmatisation AT users can experience when using devices, and shortfalls in communication amongst professional groups and between professionals and users. These issues can lead to abandonment of AT devices. Furthermore, substantial barriers to healthcare professionals exist, including inconsistent provision and quality of training, lack of evaluation of training, lack of resources and funding, shortage of qualified professionals to teach, and the increasingly rapid development of the technologies.

Conclusion: Support, training and education for prescribers, distributors, users, and their carers is vital in the adoption and use of AT. Evidence indicates a need for comprehensive education in the AT field, as well as ongoing assessment, updates and evaluation which is embedded in programmes.

Keywords: literature review, challenges adopting AT care solutions, AT training of healthcare professionals

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A Survey of Assistive Technology (AT) Knowledge and Experiences of Healthcare Professionals in the UK and France: Challenges and Opportunities for Workforce Development

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Background: Assistive Technologies (AT) in healthcare can increase independence and quality of life for users. Concurrently, new AT devices offer opportunities for individualised care solutions. Nonethe-less, AT remains under-utilised and is poorly integrated in practice by healthcare professionals (HCPs). Although occupational therapists (OTs), physiotherapists and speech and language therapists (SLTs) consider that AT solutions can offer problem-solving approaches to personalised care, they have a lesser understanding of application of AT in their practice. In this paper, we report findings of a survey on AT knowledge and experiences of HCPs in UK and France. Training needs also explored in the survey are presented in a separate paper on development of online training for the ADAPT project.

Method: A survey of 37 closed/open questions was developed in English and French by a team of healthcare researchers. Content was informed by published surveys and studies. Email invitations were circulated to contacts in Health Trusts in UK and France ADAPT regions and the survey was hosted on an online platform. *Knowledge* questions addressed AT understanding and views of impact on user's lives. *Experience* questions focussed on current practices, prescription, follow-up, abandonment and practice standards. 429 HCPs completed the survey (UK = 167; FR = 262) between June and November 2018.

Key results: Participants were mainly female (UK 89.2%; FR 82.8%) and qualified 10+ years (UK 66.5%; FR 62.2%). A key group in both countries were OTs (UK 34.1%; FR 46.6%), with more physiotherapists and SLTs in UK (16.8%, 16.8%; vs. FR 6.5%, 2.3%), and more nurses in France (22.1% Vs. UK 10.8%). More HCPs were qualified to degree level in France (75.2%; UK 48.5%, $p < 0.001$). In terms of knowledge, all HCPs agreed that AT helps people complete otherwise difficult or impossible tasks (UK 86.2%; FR 94.3%) and that successful AT adoption *always* depends on support from carers, family and professionals (UK 52.7%; FR 66.2%). There were some notable differences between countries that require further exploration. For example, more French HCPs thought that AT is provided by trial and error (84.7%, UK 45.5%, $p < 0.001$), while more UK HCPs believed that AT promotes autonomous living (93.4%; FR 42.8%, $p < 0.001$). Also, more French HCPs considered that AT refers exclusively to technologically-advanced electronic devices (71.8%, UK 28.8%, $p < 0.001$). In both countries, top AT prescribers were OTs, physiotherapists and SLTs. Respondents had little/no knowledge in comparing/choosing AT (UK 86.8%; FR 76.7%) and stated they would benefit from interdisciplinary clinical standards (UK 80.8%; FR 77.1%). A third of HCPs did not know if AT users had access

to adequate resources/support (UK 34.1%; FR 27.5%) and rated themselves as capable to monitor continued effective use of AT (UK 38.9%; FR 34.8%).

Conclusion: Knowledge and application of AT was varied between the two countries due to differences in health care provision and support mechanisms. Survey findings suggest that HCPs recognised the value of AT for users' improved care, but had low confidence in their ability to choose appropriate AT solutions and monitor continued use, and would welcome AT interdisciplinary clinical standards.

Keywords: survey of AT knowledge and practice experiences, healthcare professionals, UK, France

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Training Needs and Development of Online AT Training for Healthcare Professionals in UK and France

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Background: Assistive Technology (AT) solutions for people with disabilities has become part of mainstream care provision. Despite advantages of AT on offer, abandonment and non-compliance are challenges for healthcare professionals (HCPs), introducing this technology to clients. Studies of abandonment reveal that 1/3 of all devices provided to service users end up stored unused. Key need is training to make informed decisions about AT tailored to individual needs and circumstances. In an online survey undertaken by the ADAPT project, HPCs identified AT training needs and barriers. Currently, a programme is being developed aimed at introducing AT concepts and enhancing practices to a wide range of HCPs.

Method: Survey questions explored gaps, availability, qualifications and barriers to AT training in England and France. A series of consultation meetings with ADAPT partners took place. An advisory group consisting of longstanding AT users and their formal/informal carers and HCPs (occupational therapist, speech and language therapist, psychologist and biomedical engineer) contributed to the discussions on survey findings, development and evaluation of AT training for HCPs, key content areas and means of delivery.

Key results: HCPs had no AT specific qualifications (UK 94.6%; FR 81.3%) nor in-service AT training (UK 65.1%; FR 66.4%). They either did not know of AT courses (UK 63.3%) or knew that none existed (FR 72.5%). Barriers to AT training were mainly local training (UK 62.7%, FR 50%) and funding (UK 62.7%, FR 55.7%). Some training priorities were clearer for French HCPs – overall knowledge of AT devices (82.1%, UK 45.8%), customization of AT (65.3%, UK 30.1%), assessing patient holistically (53.4%, UK 25.3%), educating patient/carers (56.5%, UK 28.3%) ($p < 0.001$). Variances may be due to differing country-specific HCP education approach. A third of both groups highlighted also abandonment, client follow-up, powered wheelchair training and prescribing AT.

To bridge gaps in knowledge and identified training needs of HCPs, the online interactive training programme starts by introducing foundations of AT, including definitions, types/uses of AT, legislation/ policies and AT in practice. More specialist units build and expand on specific areas, e.g. AT for mobility, communication, assessment and evidence-based practice. The biopsychosocial model of Health and World Health Organisation's (WHO) International Classification of Functioning, Disability and Health (ICF) framework underpin development of content. ICF shifts focus from disability to health and functioning, in line with a social model of rehabilitation.

E-learning comprises existing videos, AT textbook material and bespoke animated presentations. Self-assessment and evaluation of training are embedded and learners receive certificate of completion. Training was piloted to a group of HCPs trainees and post-registration HCPs who commented on relevance of AT content, clarity, accessibility of presentation, and usefulness. Users found training very useful, especially legislation/policies and AT literature.

Conclusion: Overall, survey results suggest that both UK and French HCPs' training on AT solutions is limited and highly variable. There is need for cross-channel AT professional competencies, availability of work-based training and funding support. Development of online, interactive training aims to increase professional confidence and competence in this area as well as the evidence base for AT.

Integrating Ride Dynamics Measurements and User Comfort Assessment to Smart Robotic Wheelchairs

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Background: Individuals relying on wheelchairs for mobility are subject to risk of injury due to exposure to whole-body vibrations for prolonged time as per ISO 2631-1. Our study evaluates the feasibility of integrating ride dynamics measurements (i.e. vertical accelerations) as expressions of user travel comfort assessment to smart robotic wheelchairs. This will also help to mitigate injury risk and discomfort by using real-time electronic measurement systems to ensure adaptation of wheelchair movement dynamics (acceleration and speed) to the type of ground surface.
Method: The INVACARE Spectra XTR2 electric wheelchair, weighting 98 kgs, was used in seven different surfaces, indoors and outdoors. It was driven for fifteen minutes by one of the authors (body mass 88.6 kgs, height 185 cm) for 322 meters. The surfaces were: Uneven Pavement Slab, Damaged Tarmac Road, Undamaged Tarmac Road, Pavement Bricks, Carpet Floor, Tiled Floor, and Inclined Concrete. Average travel speed was 0.339 m/s. In-house designed sensor devices were placed on the metal frame of the wheelchair (location without suspension) and under the seat (location with suspension). Collected data was filtered and analysed using MATLAB. For each terrain type, the mean, standard deviation, minimum, and maximum of vertical accelerations were calculated, along with Maximum Transient Vibration Value (MTVV). MTVV measures the maximum amplitude of instantaneous frequency-weighted acceleration at measurement time. ISO 2631-1 and related literature suggest MTVV as one of the main indicators of injury risk and ride comfort.
Key results: Results show, for both with and without suspension measurements, Tiled Floor has the highest MTVV, indicating it would be the most uncomfort-

able and, depending on the value obtained, the riskier to cause an injury if traversed for long time. Different types of tiled floors would produce varied MTVV measurements. For this reason we propose that a continuous monitoring system is required to be integrated to smart wheelchairs. In most cases, maximum accelerations and MTVV were higher when measured with suspension than without. Our hypothesis is that suspension has dampening effects on vertical accelerations caused by the unevenness of the terrain, but, it can, under certain conditions, attenuate also the overall amplitude. Thus, it is important to measure both affected and not affected by suspension locations. Remaining tested surfaces were ranked for discomfort as expected (using MTVV and mean vertical acceleration statistics), with Pavement Bricks second and Damaged Tarmac Road third, while Undamaged Tarmac Road produced the lowest values (i.e. less overall vibration).
Conclusion: Different terrain types produce levels and types of vibrations which are not properly mitigated by the usual wheelchair suspensions (typically based on dual springs). This affects ride comfort (expressed by MTVV measurements) which should be considered in smart wheelchair controller design to improve user experience enhancing safety and wellbeing. Our electronic controllers integrate real-time measurements to a shared-control assistive driving algorithm, based on a deep learning artificial intelligence training procedure. This leads to adjustments of wheelchair speed and acceleration obtained from the shared (user/AI-based) controller for better ride comfort and reduced injury risk.
Keywords: Maximum Transient Vibration Value (MTVV), Ride comfort assessment, Smart wheelchair, Artificial Intelligence shared-control algorithm.
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A Smart Posture Monitoring and Correction System for Wheelchair Users

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Background: Wheelchair users may experience discomfort and ulceration from continuous sitting. Seating pressure distribution is typically assessed using expensive multi-point measurement mats, not appropri-

ate for real-time posture assessment during everyday use. Existing solutions include cushions inflating and deflating alternate air chambers embedded in the cushion. These systems operate without user posture feedback, leading to further ulceration. To address this, we propose a smart monitoring system to continuously assess user posture and selectively adjust a cushion to alleviate pressure and potentially correct posture orientation. The proposed system measures pressure distribution and adaptively controls air pressure in the cushion to automatically re-adjust posture. This aims to reduce the need of support from carers and reduce ulcers risk and general ride discomfort caused by posture changes resulting from collisions or vibrations.

Method: First, we map pressure distribution to determine areas of high interface pressure by low cost force sensors (Force Sensitive Resistors – FSRs) placed on the seat. Two types of FSRs are used; one square (4.5 cm $\times$ 4.5 cm), and one disc-shaped (2 cm diameter), placed at seven locations on the seating area, two at the front, two at the back, one in each side, and one in the middle of a 5×5 grid on the 45 cm $\times$ 45 cm cushion. Five different posture inclinations were tested (wheelchair at horizontal surface): straight, right, left, forward, backward leaning. Participants were instructed to lean approximately 20 degrees from vertical. One further condition tested with the wheelchair at 10 degrees inclination (17% surface lateral rise). This represents riding on an inclined pathway (pavement drainage rise 2% to 5%). We tested two subjects representing approximately the minimum and maximum of mass and height for the wheelchair used: 1) mass 110 kgs, height 185 cm, 2) mass 50 kgs, height 165 cm. Tests were contacted on hard seating surface (no cushion) and on normal cushion. Each measurement lasted for 30 seconds taken as the mean of sampling at 500 ms intervals. Following pressure changes detected, posture was adjusted using air supply to four air chamber regions independently. Air pressure was measured and controlled electronically by pneumatic valves.

Key results: Compared to XSENSOR mat (benchmark baseline) both types of FSR sensors provide consistent measurements for different inclinations (std $\pm$ 1% mean value). Measuring pressure using a cushion substrate provides more reliable data (no sensor data failures). Also, for left, right leaning, pressure reduction in opposite side provided higher value indicators of corresponding inclination. Front and back sensors provided unreliable measurements due to differences in seating contact area resulting from footrest height. The cen-

tre of seating area sensor produced many failures (consistent with XSENSOR mat indicating low pressure at this location). Finally, small sensors (discs) gave higher rates of change (-45% to -50%) than larger FSRs (-22% to -38%).

Conclusion: Body posture or wheelchair inclination can be estimated reliably using disc shaped FSRs at appropriate wheelchair cushion locations. Measurements are proportional to corresponding inclinations and can be used to control our innovative electronic pressure control for air tube-based cushions to correct at least 12% of corresponding posture inclination, thus improving user ride comfort.

Keywords: Seating posture monitoring, Posture correction, Smart wheelchair.

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Special Thematic Session 16
AT2030: A New Approach

Globally, one in ten people who needs assistive products and services to maintain or improve their lives has access to them. This number is increasing whilst the gap between need and provision is growing.

At the Global Disability Summit two initiatives – AT2030 and ATscale. ATscale is a new global partnership for AT which aims to accelerate access to AT and AT2030 is the first programme of ATscale. AT2030 has been designed to be 'fast start' – it is an intentionally flexible and exploratory programme, designed to test 'what works' in getting life-changing Assistive Technology (AT) to the people that need it the most.

AT2030 is comprised of six programmes and our special session reports on key learnings and challenges from each programme. The six programmes are:

1. Coordinate evidence and research – is developing new models for return on investment and creating a market shaping framework methodology.
2. Spark Innovation – is creating an Innovation Hub in Kenya linked to a challenge fund and testing new innovations in low resource settings.
3. Drive availability & Affordability – is testing market shaping methodologies, creating market shaping tools and pilot test market interventions.
4. Open-up Market Access – is developing new models of integrated AT service provision.
5. Build Capacity and Participation – is working in informal settlements in the global South. Scoping community-led solutions to AT, researching community-led practice and inclusive approaches.

6. Support ATscale the Global AT Partnership.

We welcome debate on the future direction of AT2030 and ATscale.

Chair: *Cathy Holloway*

ATscale – Meeting the Global Need for AT Through an Innovative Cross-sector Partnership

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Background: Today, over 1 billion people need at least one form of assistive technology (AT), but 90% do not have access to the AT they require. The number of people who need AT is expected to grow to more than 2 billion people by 2050. Despite evidence and consensus around the huge unmet need for AT globally, research shows a wide range of systemic, underlying environmental challenges and cross-cutting factors contributing to the challenge in matching appropriate supply and demand for AT. While progress has been made in improving many aspects of AT delivery, the sector has been fragmented and under-resourced for some time. The environment is poised for change, as countries begin recognising the necessity of AT coverage to realise commitments to the Sustainable Development Goals and the UN Convention on the Rights of Persons with Disabilities. To uphold these commitments and influence the complex systems for AT access, a broad set of stakeholders across sectors is needed to invest in and coordinate a multi-faceted, systematic approach spanning market shaping, capacity development, and policy reform.

Method: In early 2018, consultations and initial landscape analyses were conducted to better understand the barriers and scope of challenges to increasing access to appropriate, affordable AT, particularly in low- and middle-income countries. This included review of past interventions and approaches, as well as discussion about current barriers observed throughout the AT ecosystem. Information gathered through this process was considered in a series of meetings and workshops to develop a framework for a new partnership model with the potential to address these gaps.

Key results: An understanding that transformational change requires market shaping approaches to address supply and demand-side barriers, supported by an enabling environment, emerged from the broad consultation and analysis. Building this enabling environment must include galvanising political will, mobilising resources, increasing awareness, addressing policy, and strengthening systems and service delivery. Accomplishing this requires a cross-sector partnership acting as a catalyst for change, amplifying existing work, and coordinating and mobilising global stakeholders. In July 2018, this vision was realised with the launch of ATscale, the Global Partnership for Assistive Technology, at the Global Disability Summit. Eleven organisations joined ATscale's Forming Committee with a goal of reaching 500 million more people with life-changing AT by 2030. ATscale has established its initial strategy and has set out to develop a long-term operating model. Several early interventions to support the ATscale strategy are being undertaken by AT2030, a UK aid funded programme.

Conclusion: This Partnership will enable partners working in distinct sectors to collaborate with a unified mission, facilitating complementary approaches, innovation, and capacity building. The coordinated approach of convening a broad range of leading stakeholders across sectors will increase access to affordable, appropriate, and high-quality AT products and services, leveraging current and past work to address the entire AT ecosystem. The initial work, including the strategy overview, already reflects diverse perspectives and the opportunity provided by a collective effort, supporting the global community to have an impact greater than the sum of its individual parts.

Keywords: ATscale, Cross-sector, Partnership, Access.

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Increasing Access to Assistive Technology by Addressing the Market Barriers: A Market Shaping Approach for Wheelchairs

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Background: Market barriers limit both supply and demand of appropriate AT in low- and middle income countries (LMICs). Market shaping aims to break the vicious cycle of low supply, low private investment, limited competition, and high prices that perpetuates low demand. Market shaping has proven successful in increasing access to global health products including vaccines and antiretrovirals, leading to hypothesize that these approaches could also be applied to AT markets. ATscale, the Global Partnership for AT, aims to mobilise global stakeholders to shape markets in line with a unified strategy. To inform this strategy, it is critical to identify specific interventions required to shape markets and overcome barriers. Wheelchairs are the first assistive technology undergoing analysis, which is being delivered by Clinton Health Access Initiative under the UK aid funded AT2030 programme. WHO estimates that 75 million people need an appropriate wheelchair and most lack access. The market for appropriate wheelchairs in LMICs is highly fragmented and characterized by limited government engagement, limited investment, and low willingness-to-pay and is dominated by cheaper, low quality wheelchairs failing to meet end-user needs. Non-governmental organizations (NGOs) have attempted to fill the need for context-appropriate wheelchairs, but market uptake is limited. These initial findings led ATscale and AT2030 partners to believe that market shaping could support increased access to appropriate wheelchairs.

Method: To develop a robust understanding of the market landscape and identify opportunities to increase access to appropriate wheelchairs, a mixed-methods approach is used including a grey literature review, market data analysis, key informant interviews, and site visits. The analysis outputs are captured in a market shaping strategy document that incorporates a market landscape, key barriers, and identification of market shaping objectives, recommended interventions and outcomes. The authors have sought input from experts, suppliers, and stakeholders throughout the drafting and stakeholders will provide feedback on proposed interventions through virtual roundtable discussions prior to finalization.

Key results: The process led to recommendations on marketing shaping interventions to increase access to wheelchairs. On the demand-side, incorporating proven models for provision in the health sector in line with WHO Guidelines may stimulate appropriate provision and increase predictable demand. Tools to support countries to develop roadmaps for integration around financing, policy, provision and procurement

will be important enablers. Pooling resources though innovative financing, such as co-financing, may decrease fragmentation of resources available and catalyse demand. On the supply-side, the development and adoption of specifications and preferred product profiles (PPP) may strengthen procurement for context appropriate wheelchairs, decrease market fragmentation and increase market transparency. Mechanisms to secure a reliable supply for a range of affordable AT may require an approach combining technology transfer or licensing from manufacturers, regional distribution systems, and local assembly (rather than manufacturing).

Conclusion: This work provides evidence to inform ATscale's strategy and investments and will continue to inform the approach and reach of AT2030. Interventions may include additional evidence generation, development of tools to support decision-makers or piloting models of financing, provision or supply. The same process will be used for other priority AT.

Keywords: Market Shaping, Wheelchairs, Access.

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AT2030 – Exploring Novel Approaches to Addressing the Global Need for AT

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Background: It is well known that the provision of assistive technology (AT) is a 'wicked' problem and one

that requires new thinking to solve. AT2030 is a programme of investment which is part of a new global movement, to find new cross-sectoral approaches to AT provision and use. AT2030 was designed based on a scoping study into the barriers affecting AT provision. The scoping study had the objective of answering the following two questions:1) What are the barriers which prevent access to AT for the people who need it, with a focus on those living in low resource settings within the UK Department for International Development (DFID) priority Global South countries? 2) How should DFID, in partnership with others (including particularly other donors), best direct its interventions toward overcoming these barriers?

Method: The method used was flexible and iterative in nature. It sought to bring in expertise from across a diverse set of stakeholders and organisations. The emerging ideas were tested through stakeholder interviews and discussions and were refined though partner workshops and external events. The methodology was characterised by a participatory and consultative process, with clear objectives, and was both inclusive and transparent. This provided an opportunity to reflect on the applicability of evidence in different contexts and promoted dialogue among different types of stakeholders. Due to its rigour, flexibility and appropriateness in summarizing relevant features of complex datasets including different sources, thematic analysis was chosen as the analysis method for this scoping research.

In total 18 sets of field notes alongside transcripts of 23 semi-structured interviews were analysed. These data sources had been collected during meetings with stakeholders such as funding agencies, research partners and AT providers. Interviewees worked in different developing countries and were employed in various sectors including academia, industry and NGOs. These were supplemented with two deep-dive scoping exercises conducted in Kenya and Uganda. This corpus of data was analysed and coded using a hybrid deductive and inductive approach.

Key results: Our work reveals differing levels of AT market development across countries. However, the key barriers are common. Five broad areas to categorise barriers, facilitators and opportunities for improving AT access in developing countries were identified and prioritised according to the 5Ps model formulated by GATE: People, Products, Policies, Provision, Personnel.

Conclusion: We found the challenge of AT provision represents a complex web of market and systematic market failure, compounded by a lack of participation

from the communities that have the best knowledge of the issues (users themselves). This results in a mismatch between supply and demand which affects almost a billion people. This makes AT access one of the most pressing problems facing the global health sector.

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Innovate Now: Creating an Assistive Technology Innovation Ecosystem in Nairobi

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Background: In Kenya there are at least 2 million people with disabilities and approximately 67% of them live below the poverty line. Being able to access appropriate assistive technology (ATs) is fundamental to ensuring people are able to improve their access to opportunities for education, livelihoods and life generally. Unfortunately, currently available ATs are often inadequate, too expensive and delivered through services which are unable to keep up with the demand. The Kenyan entrepreneurial spirit and technological creativity are renowned across the world. This creates a potential fertile ground for AT innovation where new technologies and disruptive service delivery systems are developed to increase access to AT, and to boost economic opportunities across the country. Although AT innovation could represent a lucrative opportunity for many tech entrepreneurs, only a few start-ups focus their efforts in the area. This is partially due to a lack of awareness, but it is also linked to the difficulty of bringing products to market in a field where ideas need to be tested with hard-to-reach populations and complex regulatory systems need to be navigated.

Method: Interviews with stakeholders were carried out to identify needs and difficulties of start-ups developing products for the AT market in low resource settings. Interviews were conducted with entrepreneurs, experts in the field of AT, accelerator and incubator managers and venture capitalists. Two scoping visits were also conducted to Kenya to map the innovation landscape and understand the gaps within the services currently provided to entrepreneurs. Negotiation meetings were held with potential partners to better define the role of NGOs, government agencies and the private sector within the innovation ecosystem.

Key results: Results from the interviews with stakeholders show that the barriers encountered by startups in the field of AT are many and varied. Some of the needs of AT startups are related to business planning, legal expertise marketing mentorship, which can be addressed by traditional incubators and accelerators programmes. However, AT startups also encounter difficulties in gaining access to environment where they can test and develop their products, receive feedback from people with disabilities and gather the strong evidence they need to secure funding from donors and venture capitalists. Reports from scoping visits demonstrate that Kenya has a wide network of incubators and accelerators that could support the activity of AT startups. However, these organizations are often disconnected from people with disabilities and NGOs who work on the ground, which limits the impact of the services they can provide.

Conclusion: To address the gap highlighted by our investigation, the Global Disability Innovation Hub thanks to the support from the UK Department for International development, has created the Innovate Now ecosystem which aims to support entrepreneurs throughout their journey and help their products to reach the market more quickly. The Innovate Now Ecosystem is funded through a network of partnerships involving government, private businesses, NGOs and academic institutions where each partner has a specific role and provides contextual support and expertise to new start-ups who have developed innovative ATs.

Keywords: Innovation Ecosystem, Assistive Technology, Start-up, Incubator.

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Moulding a New Prosthetic Service Delivery System with the Amparo Confidence Socket

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Background: Lower limb amputation is a major surgical procedure that can completely change a person's life. Thanks to lower limbs prosthesis, amputees often regain their independence, resuming their desired roles in family and social life. Unfortunately, many amputees who live in low and middle income countries do not have access to the prosthetic services that they need. Without an appropriate prosthesis, amputees often remain dependent on family and community and are unable to access basic rights such as food, shelter, education and work. One of the main factors responsible for the difficulty of providing appropriate lower limb prosthetics is the high cost associated with their fabrication. In turn, this is mainly linked to the need to rely on specialized health care workers and expensive workshop equipment for most of the manufacturing process. Generally, making a lower limb prosthetic is a highly individualised process and requires on average 8 hours of work time from the healthcare professional with two of these hours spent with the patient on two separate visits.

Method: Amparo Gmbh has developed a new thermoplastic pre-assembled socket that can be molded directly on the residual limb of the amputee, thus drastically reducing the time, tools and expertise needed to manufacture lower limb prosthesis. The pre-assembled socket is also fitted with the attachment point, allowing the technicians to easily connect the socket with the terminal part of the prosthesis. The low-temperature thermoplastic allows the socket to be remolded several times to accommodate changes in the residual limb which are common after amputation. Finally, the equipment needed to manufacture a lower limb prosthetic with the Amparo socket can easily be packed in a standard suitcase, making possible to adequately fit lower limb prosthesis within. To understand the benefits of the confidence socket we carried out observations of during socket fitting procedures and informal interviews with both prosthetic technicians and below the knee amputees who are currently using the product.

Key results: The socket has received positive reviews from both amputees and healthcare professionals. Technicians particularly appreciated the ease of use and how quickly they could fit the socket and test the prosthesis with their patients. Amputees praised the comfort of the socket and were impressed with the fact that the socket eliminates the need for multiple visits and the waiting time when modifications have to be made. Amparo is currently working with the Global Disability Innovation Hub and local partners to trial the thermoplastic socket in Kenya to assess the feasibility and acceptability of the new technology with the local workforce.

Conclusion: To reducing the cost, time and skills required to fit lower limb prosthetics. Its impact is potentially greater in low and middle income countries where shortage of human and material resources make

providing appropriate prosthesis a particularly complex issue.

Keywords: Lower Limb Prosthetics, Amputees, Prosthetic Technicians.

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Developing Tablet Audiometry for Screening Children's Hearing in Tanzania

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Background: WHO has estimated that there are around 466 million people worldwide that have a disabling hearing loss, and 34 million of these are children. The majority of children with hearing impairment live in low-income countries, and in Sub-Saharan countries most children with hearing impairment remain undiagnosed, untreated and without the provision of adequate services and devices. The current provision of hearing aids is inadequate across most low- and middle-income countries. For the individual child, hearing loss normally has a large impact on life because the loss of hearing affects the development of speech, language and cognitive skills. Public awareness and attitudes towards childhood disability in low- and middle-income countries are often poor, and may lead to social isolation, stigmatization and exclusion from education and employment. The objective of the research has been to develop new appropriate tools for screening children's hearing in local communities in low- and middle-income countries, and to assist children with hearing loss to attend school and participate in society. The research project specifically addresses the topic of Inclusive Education and the UN Sustainable Development Goals Nr 4 on Quality Education.

Method: A participatory research design and co-design process characterised by user involvement and iterative design processes were selected. The iterative process includes problem definition, identifying user needs, defining system specifications, developing technology, prototyping, testing and evaluation involving users and relevant stakeholders. The prototypes have been refined according to the knowledge gained in the testing, before passing onto a new iteration. Qualitative research methods have been applied for providing user needs and a better understanding of the situation for children with hearing impairments and include individual interviews, focus group interviews, questionnaires, field studies and observations involving children, parents, school teachers, hearing experts, authorities and NGOs.

Key results: A new tool for community-based screening of children's hearing has been developed. The screening tool have been tested at primary schools in Tanzania and the screening tool is based on the concept of gaming and consist of commercially available tablets, headphones and dedicated software developed by the project. The game-based tablet audiometry has been validated with reference to traditional audiometry and tested. 407 children in primary school in Tanzania have participated and been screened for hearing loss, measuring the hearing thresholds of 25 dB with tablet audiometry and traditional audiometry. The paper describes the development process and present the results from testing and validating the tablet audiometry at primary schools in Tanzania.

Conclusion: The new screening tools using game-based tablet audiometry has the potential of facilitating the development of local hearing services in low- and middle-income countries and screening children's hearing at local schools without expensive and specialised equipment. Special teachers and school teachers will do the screening. Awareness and identifying children with hearing impairments is the first step towards Inclusive Education and participation.

Keywords: Children with hearing mpairment, Hearing loss, AT in low-and middle-income countries, Tablet audiometry, Disability.

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Assistive Technology Services for School Children with Disabilities in Tanzania: The Role of NGOs and the Need for Intersectoral Coordinations

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Background: According to UN, less than 1% of school-aged children with a disability in Tanzania are enrolled in school. Tanzania developed an Inclusive Education Strategy to ensure equitable access to quality education for all. Tanzania has no national procedures to assess the needs of children before enrolment in school. District-level educational resource and assessment centres were suggested in 2013, including screening and referral for assistive technology (AT) provision. Yet, rehabilitation services and AT systems for children with impairments are poorly developed and often inaccessible or unaffordable in a country with 55 million inhabitants. The aim is to discuss how public-private collaboration, NGOs and intersectoral coordination may contribute in fulfilling children with disabilities' rights in education and health, rehabilitation and AT provision.

Method: The discussion is based on previous case-study research and recent data collected through multi-sited ethnographic fieldwork and visits in public and private rehabilitation- and education institutions and NGOs in rural/urban Tanzania since 2012, and experience-based knowledge. Methods included document and literature-review, participant observation and interviews of stakeholders in disability-related organizations and parent associations.

Key results: Public and private rehabilitation institutions providing AT have increased in number, in particular in urban areas with specialised hospitals, for-profit enterprises and not-for-profit NGOs. For the growing middle-class, advanced AT (for ex. cochlear implants) is available, or can be purchased abroad. Yet many children with disabilities (CWD) who live in rural areas may never access basic AT such as spectacles, crutches or wheelchairs. NGOs seem though to contribute significantly in rehabilitation and inclusive education. In three decades, Comprehensive Community Based Rehabilitation (CCBRT) has become Tanzania's largest provider of rehabilitation services, with a hospital, CBR units, AT production centres, and outreach throughout the country. As a social enterprise serving the most vulnerable, they collaborate across sectors, and invest in prevention, advocacy and training, promoting early identification and follow-up through innovative ICT and "ambassadors". Quality-services for children and the poor are increasingly financed by income generated through a private clinic.

In the special education sector, privatisation has increased the number of schools. However, in public schools, very few special education teachers, lack of appropriate resources and rare specialised assessment centres, with inadequate budgetary allocation, results in poor AT support. At the same time, some local and international NGOs collaborate with the Ministry of Education implementing district assessment centres, developing operational tools for identifying and documenting the needs of CWD, and providing and referring them for services.

Conclusion: In spite of policies affirming the right to education for all children in Tanzania, need-assessment and AT provision is still random, with rare public support to enable quality services. Some disability-NGOs apparently address children's special health- and education needs early, also in marginalized locations, increasing availability, accessibility and affordability of services, while investing in advocacy, community empowerment and competence building, mobilizing funding, and pursuing sustainability. Government commitment and national coordination of AT services across health-, education and social sectors, and public-private collaboration may promote a more equitable distribution of AT services, thus allowing education for all.

Keywords: children with disabilities, assistive technology systems, Tanzania, NGOs, inclusive education.
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Comprehensive Approach to Assistive Technology in Low-income Country: A Case Study of CRP Bangladesh

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Background: Assistive technologies (AT) encompass a wide range of technologies and devices that maintain and improve individual's functioning, independence and participation. Equal access to AT is included in the Convention on the Rights of Persons with Disabilities. WHO estimates that only 5%–15% of people who require AT in low- and middle-income countries have access to them, and this is true for Bangladesh as well. An estimated 1.6 million Bangladeshis need a wheelchair and 800,000 need an orthotic device. There are no facilities for large scale production of ATs, no official distribution system, no financial support for provision of AT for persons with disabilities, and no

planned approach to AT imports. Although imports increase AT availability, it is not known whether they are fitted properly and what kinds of consequences that may have on psychological, social and physical functioning. There are very few qualified rehabilitation professionals who are trained to prescribe individualized AT. Also, there are many environmental barriers that prevent participation of persons with disabilities. The Centre for the Rehabilitation of the Paralysed (CRP), a non-governmental organization, was established in 1979 to offer services to people with spinal cord injuries, children with cerebral palsy and adult neurology patients. It has grown from a four-bed unit to a 140-bed hospital with 12 regional rehabilitation centers, and an accredited academic branch that offers 11 diploma, bachelor's and master's programs in physiotherapy, occupational therapy, speech and language therapy, nursing, prosthetic and orthotics and rehabilitation science. This case study aims to contribute knowledge on AT production and distribution in Bangladesh, through examining promising CRP practices.

Method: This qualitative case study documents an approach to small scale production and distribution of AT. It presents the results of the content analysis of the relevant documents, articles, case studies and artifacts that were collected, reviewed, and complemented with observations at CRP Bangladesh in January 2019.

Key results: CRP has a comprehensive approach to AT production, distribution and follow-up for its patients in community and hospital settings. Over time, CRP has developed specialized units dedicated to production of various types of AT: appropriate paper technology, wheelchair and mobility devices workshops, special seating, hand therapy (splinting), and prosthetic and orthotics. CRP's approach to the provision of AT is based on principles of availability, affordability, adequacy, acceptability, appropriateness and quality (5As+Q). CRP increases AT availability by producing low cost and affordable devices. AT adequacy is ensured by individually fitting each device to meet user's needs, increasing the acceptance of the device by users. CRP ATs are made of locally available materials also considering the local environment and infrastructure. CRP AT services are of high quality, provided by qualified multidisciplinary rehabilitation teams with professionals trained at bachelor's level. They assess, prescribe devices and follow-up patients using telehealth, phone, or home visits to ensure modifications are done according to the changing needs of persons with disabilities.

Conclusion: The CRP's 5As+Q approach that ensures access to AT for its patients is context-sensitive and can be replicated and scaled up.

Special Thematic Session 17
Care Robotics in Europe and Asia; A Multicultural Perspective

As ageing is a worldwide phenomenon international collaboration is increasingly important. This session highlights Care Robotics research and development in Asia and Europe. This is a fast developing field and the market for care robotics is expected to grow rapidly. In Asia as well as in Europe much research and development work is being done. The aim of this session is to present an overview of this work and to discuss differences and similarities between Europe and Asia, with a view on learning from each other and increasing the applicability of robotic solutions across continents. The focus is on care robot devices to enhance the quality of life of people with disabilities, elderly people and caregivers. During the session there will be sufficient time for discussion and input from the participants.
Chair: *Luc de Witte*

Care Robotics Development: A European Perspective
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Background: Care robotics is an area of assistive technology that promises much but has, as yet, delivered little. Excluding the specialist area of surgical robots, and notwithstanding the hype around robotics, it seems that few care robots are currently to be found in use on a day-to-day basis anywhere in the world. The most obvious reason for this would seem to be the relative immaturity of robot technology; however, there could be other causes: failings in the design and development processes, for instance, or structural deficiencies in the ecosystem that sustains the care robotics economy. The authors have probed the current state of the European

care robot development community and the causes of the apparent lack of practical results; this paper reports their findings.

Method: The authors conducted an internet-based analysis of care robotics companies worldwide, and performed an assessment of the market positioning of each and the state of its robot offerings based on current product and service availability, the evidence of peer-reviewed papers, its involvement in externally funded research programmes, and other supporting material. Focusing on the European experience, a workshop with experts in the field explored the issues around care robot applications, and a follow-up questionnaire was used to widen the scope to encompass other opinions.

Key results: The study confirmed the impression that, within Europe, care robots use is limited to, at best, standardized, repeated, localized, non-critical and low-risk tasks that require little robot intelligence or autonomy. In large part this is because the technology is not yet sophisticated enough; but also because the practical issues of introducing robots into complex care contexts and, to a lesser extent, safety, legal and regulatory concerns have not been satisfactorily addressed. However, it also revealed that there are structural weaknesses in a European care robotics ecosystem that relies heavily on public funding (at a national and supranational level) and is populated by micro and small enterprises, and university research departments. Perversely, this model serves to incentivize the development of robots that secure subsequent public funding rather than those that address real end-user requirements. Furthermore, the lack of appropriate instruments for assessing the holistic cost-effectiveness of care robots alleviates the 'evolutionary pressure' to develop better robots and robot services.

Conclusion: In general care robotics is (probably) the most challenging area of robotics: it involves long-term interactions with vulnerable people in complex, dynamic environments, and as such the apparent immaturity of the field is hardly surprising. It is clear that much effort, perhaps driven by more commercially focused domains, is still required to develop the fundamental robot and AI technology and to improve interfaces, reliability and safety. Moreover, we believe that the rate of development could be improved by the development of whole-lifecycle evaluation methodologies, by the greater involvement of potential service users in the design process, and by incentives that reward a greater willingness to risk exposing care robotics to real users.

Keywords: Artificial Intelligence, technology ecosystem, research and development, robotics.

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Planning Care Robot Project in Korea Based on User Centered Approach and its Future Direction

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Background: Korea faces an aging population, and care robot market is expected to grow rapidly. Though development and dissemination of care robot in Korea has not been prepared yet, some countries are already carrying out large-scaled national projects on care robots. The objective of this abstract is to document the iterative procedure used to identify needs, selection, and planning of care robot project in Korea based on user centered approach.

Method: Based on literature review, field observation of real space and people, in-depth & focus group interviews of various stakeholders, we identified the needs of care robot and selected care robot categories in Korea. Also we set up and held "Care Robot Network Forum ($n = 49$)" with various stakeholders including caregivers, care-receivers, researchers, companies, nursing homes and policy makers. Through this Forum, we carried out care robot project planning in Korea.

Key results: The results of the study in care robot project in Korea showed that there are 9 categories of requirements for care robots which is lifting, moving, changing position on the bed, toileting, eating, bathing, exercising, communication and smart monitoring. The five primary strategies of care robot projects are: 1) Intensive investment according to matching needs and technology for care robot; 2) Achievement through translational research; 3) Realization of smart care through 4th industrial revolution technology; 4) Personal-centered research with stakeholders; 5) Building a care robot ecosystem. Moreover, we need specific steps for care robot project in Korea. 1) Planning 2) Development of care robotic devices 3) Translation Research 4) Development of service model 5) Dissemination.

Conclusion: We identified the needs & selections required and planned the care robot project in Korea through this study based on user centered approach. Through this research project, we have started the first

period of Korea Caring Robot Project, which will be proceeded for four years from 2019. It is expected that joint research on the need for care robot and R&D direction considering various cultural differences will be needed in the future.

Keywords: Care Robot, Plan, Aging, Disability.

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What Should be Considered when Developing Care robots According to their Types?

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Background: The care robot project in Korea started in 2019. It is important to predict and prepare for the demands of the care robots. Based on 4P (public, private, people, partnership) approach, a questionnaire survey was conducted to identify the caring needs and consideration on the development of care robots.

Method: The participants ($n = 114$) of the survey are composed of public section ($n = 21$; policy maker, nursing home owner), private section ($n = 40$; company, researcher), informal caregiver ($n = 32$; family member) and care-receiver ($n = 21$) in Korea. The survey was conducted through online, using a survey tool called Google Survey from Oct 15th to Dec 16th, 2018. The online survey, composed primarily of checking boxes and comment fields, consisted of 38 questions. The data was analyzed through MS office excel and atlas.ti 8.0.

Key results: The results of the studies showed that the group with the greatest need for care robots is the informal caregiver group. Barriers in introducing care robot to the field include safety issues, clinical trials, field demonstration, and public benefits. For each kind of care robots, the important considerations for technology development were different; ceiling typed lift (current environment friendly device), exo-skeleton typed lift (user friendly), moving (safety), changing position on the bed (customized), toileting (hygiene), eating (customized), bathing (user friendly), exercising (customized), communication (Artificial Intelligence technology) and smart monitoring (Information).

Conclusion: The purpose of this study is to investigate the difficulty of caring and consideration of the development of care robots throughout the four groups. Through this study, we found that the main target of

care robot is the caregiver. In addition, it was found that the priorities of consideration in the technology development were different according to the types of care robots. In order to supplement the limitations of this study (small scale, online questionnaire), we need to perform usability test, user experience and technology demand analysis in the future for care robots. It is expected that this research will help to set the direction of care robot project in Korea.

Keywords: Care robots, Questionnaire survey, Caregiver, Care robot project.

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Care Robotics in Europe and Asia; A Multicultural Perspective

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Background: Service robots have the potential to support older adults with executing problematic daily activities in order to maintain their independent living. However, stereotypes often suggest that older adults tend to be less open to the idea of living with a robot. Several multi-country studies that were conducted during the ACCOMPANY (Acceptable robotiCs COMPanions for AgeiNg Years) project provide insight in the acceptability of service robots by potential users in three countries (i.e. older adults, informal caregivers and professional caregivers) and their view on how a service robot should behave in a socially acceptable manner when interacting with potential users (i.e. the preferred characteristics of such a service robot).

Method: An existing service robot, the Care-O-bot 3, and different scenarios developed by the ACCOMPANY consortium were used as concrete cases in the different studies. These were discussed and analyzed during different focus group sessions with older adults, informal caregivers and professional caregivers in the Netherlands ($n = 97$), France ($n = 173$) and the United Kingdom ($n = 62$). During these focus group sessions various topics were explored. Detailed summaries of the qualitative results of the focus groups for each country were composed from audio recordings.

Key results: The results of the studies in the ACCOMPANY project showed that older adults in all three

countries are open to the idea of having a service robot supporting them in their daily life. It was even found that the older adults had a more positive attitude towards robots than their caregivers. Participants from all three countries agreed that a service robot should always have to obey the user. All participants also wished and often even expected that a service robot could be customized to the needs, wishes and preferences of each individual user. However, no major differences could be found in the views recorded among the participants of the three different countries. There were some small differences, for example: in France the participants mentioned more issues concerning the coordination of care and the role a service robot could play to improve this, while this was mentioned less in the Netherlands and the United Kingdom.

Conclusion: Only small differences could be found in the views recorded among the participants of the three different countries. However, this does not imply that there are no differences in the perception of care robots in Europe as the participants agreed that one size does not fit all; the robot has to respond to individual preferences. This makes the development of service robots complex as it has to deal with variety between different individual users (e.g. their personal preferences and home environments). In order for a service robot to do this in an acceptable manner it would require a high level of intelligence, a level that is currently not possible.

Keywords: Service robots, older adults.

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Special Thematic Session 18
Social Robotics for Assistive Technology

Social robots in the context of assistive technology are specifically designed for social interaction with humans. Such approach plays an important role with respect to health and psychological wellbeing of those that need assistance. Assistive social robots are demonstrated to be useful in wide range of assistance from robotic therapies for children to eldercare. Two fundamental reasons are at the basis of the success of this approach: a functional and an affective motivation. Such robots are developed to function as an easy-to-interpret and immediate interface to digital technology, and, at the same time, to help increase the quality of life by providing companionship. However, no comprehensive review is yet performed to investigate the effectiveness of such assistive social robots in the care.

Therefore, we systematically reviewed some successful stories in social robotics for assistive technology and highlight the effects of assistive social robots for humans that need assistance.

Chairs: *Francesco Rea and Riccardo Magni*

Humanoid Robots: Advantages of Social Robots in the Assistance of Elders

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Background: In our research, convinced by incontrovertible evidences we propose different assistive technologies based on the proactive intervention of humanoid robots. The humanoid robots and their easy-to-interpret behaviors give the opportunity to promote acceptable assistance. Further the humanoid robot if correctly designed is more likely to be accepted as companion in the activities of daily living. Our key hypothesis is that the acceptance of robot companion has a direct and positive outcome in the assistance.

Method: With a multidisciplinary group of researchers addressing the rehabilitation of ageing individuals with mild cognitive impairment, we proposed robotic technology that proactively assist and promotes cognitive rehabilitation.

Key results: Key result is that it is more complicated to convince the traditional health care system of the benefit of the proposed technology with respect to the ageing individuals. They accept the novelty of robotic assistant more happily than predicted. The reason behind such high degree of acceptability stands in the possibility of interfacing with the technology through a companion that interacts according with known social rules.

Conclusion: The take home message is that in social robotics for assistance is important to involve the end-user user in the design in order to understand their social needs. Thanks to such understanding, the assistance can be enriched with a social dimension that promotes the level of acceptability of the technology. In the near future such interesting consideration will be proposed to partnership of interested stakeholders in the field of assistive technology.

Keywords: Human Robot Interaction, Assistive Technology, Ageing Population, Social Robotics, Humanoid Robotics.

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A Communication and Monitoring Robot System for Older People Living Alone

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Background: The number of older people living alone is dramatically increasing in Japan which in turn has led to the rise in the number of solitary deaths. This has become a disturbing social problem. Therefore, the importance of attentively monitoring older people who are living alone has recently been acknowledged. Currently, taking care and the monitoring of older people is undertaken by humans. However, due to the rapidly decreasing birth rate in Japan leading to a reduction in the Japanese labor force in the very near future, the number of care staff for older people will likely decrease. As a result, reducing the burden and work of care staff is urgently required. Therefore, we propose a robot system to assist and reduce care-staff workloads e.g. by monitoring and improving the quality of care. Our proposed system is mainly for the use of care staff of a community-based integrated care system in local communities.

Method: We have developed a communication robot system – a physical robot for older people, which utilizes the cloud network, as well as having a terminal for monitoring older people. The robots are able to speak with the older people, and can communicate local community information such as news, give daily routine cues, hold casual conversations and so forth. The user's speech is converted to plain text and an appropriate response message is found from the conversation database on the server (Cloud). The probability of the response message is calculated using Word2Vec. The robot also has physical motion functions and is installed with a three degrees of freedom motorized mechanism. The terminal for the person monitoring uses a web browser as a web page and can monitor their activity through the data from the robot. In consideration of ethical aspects, we have made it possible to monitor only simple activity records e.g. talk time, the number of counts by the human motion sensor and so forth. Additionally, the robot has the function of enabling it to make an emergency call and the monitoring persons can send messages to the robot and in turn the robot can convey these messages to the older person. Finally, a communication log is compiled and it will be analyzed and then used to evaluate the older person's activity levels.

Key results: A Communication robot system for older people who live alone has been developed to monitor, communicate and collect their activity data. Care staff belonging to the community-based integrated care system can monitor the older people through the robot. The robot, it's functions and the design of the terminal web page were checked by occupational therapists who are familiar with taking care of older people especially those with dementia. This advanced system has obtained positive evaluations from occupational therapists.

Conclusion: As a result of developing the communication robot system for older people who live alone, the next step is to actually place the robots into single, older people's homes.

Keywords: Older People Living Alone, Communication and Monitoring, Robot.

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Robot-assistive Joint Attention Training in Autism Spectrum Disorders

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Background: The advent of new technologies allows researchers to investigate subtle features of the human behavior, by dissecting it and by creating well controlled experimental paradigms. A systematic investigation of such features is desirable in order to facilitate the interaction between humans and artificial agents. Although numerous authors demonstrated the efficacy of assistive technologies in neurodevelopmental disorders, sample sizes and methods of previous studies determined dubious results. Based on previous literature results and limitations, we defined a robot-assistive joint attention training tailored to autism spectrum disorder. The training consists in a spatial attention game with the robot Cozmo, which interacts with objects lo-

cated in front of it, stimulating the child's attention. Activities include a 15 minutes interactions with the robot during rehabilitation sessions, and will be carried out twice a week for five weeks.

Method: To test the efficacy of the planned training, 38 children (29 males, age ranging from 3 to 7) and their families were involved in the activities. Prior to the activities, children diagnosis was re-assessed using the ADOS 2 and ESCS, to determine their functionality level. Clinicians and families involved in the protocol were evaluated in terms of implicit and explicit attitudes towards robots, using and Implicit association test (IAT) combined with self-report questionnaires (i.e. NARS, ROSAS, FSQ). An additional self-report questionnaire was created ad-hoc in order to assess the familiarity and the previous experience with the robots along with the expectancies toward robotics (FITTER questionnaire). We trained clinicians to autonomously control the activity of the robot. 8 children were excluded from the study after a two-week familiarization phase, due either to a lack of interest or impossibility to carry out the activities. In order to allow all children to interact with the robot, a cross-over design was adopted. The training is currently ongoing with 30 children.

Key results: Preliminary results based on questionnaires administered to clinicians revealed a positive correlation between age and discomfort perceived towards the robots ($r = 0.50$, $p = 0.03$), anxiety towards robots ($r = 0.50$, $p = 0.03$) and reluctance towards interaction with robots ($r = 0.49$, $p = 0.04$). Previous experience with the robots negatively correlated with perceived warmth during the interaction ($r = -0.48$, $p = 0.04$). Reaction times collected with IAT revealed a negative association between robots and mentalistic concepts (F = 157.45, $p < 0.001$). Qualitative reports collected from the clinicians after the familiarization phase revealed a positive attitude towards the robot from the vast majority of the children. Children from all functioning levels seem to be able to understand the task, providing either verbal or non-verbal response. Post-training improvements will be assessed with the ESCS and ADOS 2.

Conclusion: Preliminary data suggest the existence of a positive attitude towards robots both in the children and in the young clinicians involved in the activities. Despite the initial skepticism, the entire sample of clinicians reported a positive experience with the robot after the familiarization weeks. We expect the effects detected from the self-report questionnaires to change after the training, due to the increase in the familiarity and expertise with assistive robotics.

Promoting the Use of Social Robots to Engage Students with Special Education Needs (SEN): Development of a Teacher-friendly App

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Background: The use of social robots with students with special education needs (SEN) is gaining increased attention within research due to their ability to engage students in social activities. Anthropomorphic robots, for example, have been proposed as ideal social mediators encouraging engagement within student groups that find social skills difficult to develop, and by extension find traditional learning methods difficult. In addition, recent investigations have begun to show a positive impact that robots could have within SEN teaching through encouraging engagement with learning activities. Technological competence and lack of easy to use robotic platforms, however, may make the use of the social robots for SEN students difficult, increasing the likelihood that the robots will not be used in the future by potential stakeholders. In this view, the present contribution reports on the development of an app to facilitate the development of robot-based educational activities targeting SEN students and promote the use of social robots in mainstream schools.

Method: The design and development of the app followed a Living Lab (LL) approach. LL is a user-driven open innovation ecosystem which enables users to take an active part in the research, development and innovation process. In this study, a permanent panel of 5 SEN teachers were involved in the conceptualization and design of the app aimed at controlling a humanoid robot (Aldebaran NAO humanoid robot). Iterative group discussions between the SEN teachers and the development team were organized to develop a first working prototype interface running on an Apple iPad®. The prototype was pilot-tested with a student with Down Syndrome (age 8 years) and mild intellectual disability using a AB case study design. Activities proposed with and without the social robot tapped language and math skills.

Key results: The app developed allows SEN teachers to control the humanoid robot and activate learning activities without the need to connect further devices as in already available NAO controllers. The app was considered usable and easy to understand, even if further refinements are needed to ease the use of the application. The results from the case study revealed comparable results between the traditional and robot-based approach to learning, thus suggesting that the introduction of a humanoid robot is not detrimental for student's learning achievement. On the contrary, according to the opinions of the teachers, it may open novel learning scenarios.

Conclusion: Social robots are increasingly used not only 'in education' (e.g. as a support to teach technical skills), but 'for education' – that is, as a medium to teach curricular subjects. In this view, robot-mediated education is opening new learning scenarios in which the student learns from – or together with – a robot that is capable of asking questions, providing feedback and suggestions, and in general to engage the student in social interactions. More research is warranted to explore whether the use of social robots may improve inclusion in education of SEN students usually at risk of marginalization.

Keywords: Social Robots, Special Education, Intellectual Disabilities.

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