Living Labs and Open Toolkit for the co-design of accessible IT systems and tools

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LIST OF Acronyms

Acronym	Description
PwCD	People with Cognitive Disabilities
AI	Artificial Intelligence
API	Application Programming Interface
XAI	Explainable Artificial Intelligence
MCI	Mild Cognitive Impairment

1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This document aims to introduce the potential use of AI and machine learning in the LIVE IT project and in particular the potential contribution of AI and machine learning to the LIVE IT 'Open Toolkit'. It sets the aims and objectives of Task 2.3 and D 2.3 - IT and AI implications – within the context of LIVE IT as a whole; and reports on how these aims and objectives were addressed in practice.

1.2 INTENDED AUDIENCE

This document should be used as a reference by:

- European Commission
- all Consortium Partners of LIVE IT

1.3 STRUCTURE OF THE DELIVERABLE

This deliverable is structured as follows:

- Following this Report Summary, Section 2 re-visits the aims and objectives of Task 2.3 and D2.3 - IT and AI implications - as set out in the project Description of the Action (DoA) and explains how these aims and objectives changed as the project developed
- Section 3 provides a brief overview of the AI and machine learning literature within the context of web accessibility
- Section 4 touches on the specific issues experienced within LIVE IT with regard to AI, machine learning and digital interactions
- Section 5 presents the results of the alternative of AI technology implementation that LIVE IT used to map the list of tools added to the Open Toolkit to accessibility related challenges identified
- The concluding Section provides a brief summary of the key messages in the deliverable together with concluding remarks on possible future directions.

Annex I provides a set of 'Lab Packs' developed by LIVE IT to support the collection of data from experiments implemented in future Co-Labs and Hackathons. These are intended to illustrate an alternative, more traditional way of mapping tool use against challenges than the AI/machine learning route.

2 IT AND AI IN THE LIVE IT CONTEXT

The LIVE IT Description of the Action (DoA) considered IT and AI in relation to four main project objectives. Firstly, as a conceptual framework to explore the potential application of AI and machine learning to developing web accessibility. As noted in the DoA, the design and development of the Open Toolkit was intended to be informed by "an assessment of the potential of using AI to identify patterns and clusters leading to an understanding of current and future usage issues, allowing to easily develop front-end guidelines and tools". Secondly, as operational tools to capture data on participants' use of tools in the experiments carried out in the LIVE IT co-Labs and Hackathons. As described in the DoA, it was envisaged that LIVE IT would develop an AI-based tool to assess at least 100 good practice cases of platforms, development tools and authoring systems. Thirdly, as analytical and explanatory tools to identify interactions and 'causal relationships' between tool attributes and user behaviours. The idea behind this was to apply AI tools to capture relevant interactions by co-labs and Hackathons' participants with tools, so as to identify the particular combinations of attributes and learner interactions that led to 'success'. Fourthly, as part of the 'meta environment' of the Open Toolkit which would help users to navigate their way around the Toolkit. In this context, it was envisaged that the Open Toolkit would include "facilities to interlink the elements of the different directories" within the Toolkit, using AI and machine learning.

Essentially, Task 2.3, aimed to apply machine-learning tools to explore interactions between the technical attributes of the various combinations of platforms and tools used in co-lab experiments and the use behaviours of participating users. The aim of this activity was to develop clusters of attribute-use behaviour combinations that demonstrate the best potential outcomes for inclusive web accessibility. This is part of a broader objective that aims to explore the potential value-added AI systems and tools could make to support inclusive web accessibility.

This reference to AI and machine learning carries with it an implication that the LIVE IT Open Toolkit – and its supporting technical environment – would need to draw on conceptual frameworks and technical artefacts that are currently within the scope of research in areas such as meta learning and meta reinforcement learning. Meta learning within the context of machine learning essentially involves developing algorithms that make predictions by taking the outputs and metadata of machine learning algorithms as input (Kudari and Sugda, 2021). It is closely linked to meta-reinforcement learning which aims to create environments in which problem-solving 'agents' are not only able to learn rules to solve specific problems but are expected to generalise from previous training in a specific problem to apply that training in new tasks and environments not previously encountered (Wang et. al., 2017).

However, as recognised by LIVE IT's external project reviewers, our experience in the project of mapping tool attributes against user behaviours suggested that any meaningful incursion into the

fields of AI and machine-driven learning – one that has an end goal of developing AI and machine-learning 'agents' to offer solutions to user challenges - would require time, resources and multi-disciplinary expertise that were beyond the scope of this current project. The external reviewers made the following observations and recommendations in this regard:

> "The open Toolkit, as specified in the DoA, will not be achievable within the project's time frame, given its complexity.... it is unlikely that the project will gather enough data to sufficiently train machine learning algorithms to achieve decent mapping results. However, the mapping could easily be described as a table and thus made available to the public".
>
> "The Open Toolkit seems to be a referral service based on AI. This is a high-risk approach to a simple tool and is unlikely to foster new tools. Other aspects, such as the Makerspace and Hackathons seem more useful to this objective ".

These comments and recommendations provided a steer to move the project towards developing a 'recommendation' or 'advisory tool' in which the machine learning component is reduced to a simple algorithm. This tool acts in essence as a 'bridging tool' that enables the other components of the Open Toolkit to integrate with each other in a useful way. We have therefore moved away from the original conception of Task 2.3 as an activity aimed at developing an AI and machine-learning driven tool that would 'power' the Open Toolkit to a revised approach in which a much simpler 'advisory tool' was developed. This applied concepts and practices drawn from 'meta design' (Fischer and Giaccardi, 2004) to develop an advisor tool that involves "a co-adaptive process between users and a system, in which users become co-developers or co-designers". With this simplified advisor tool, users choose from one or more drop-down menus, where applicable, the challenge that they need assistance with. Answers fed to the algorithm determine the best assistive tool(s) from the LIVE IT database. The top 5 tools are displayed, and a star system evaluation provides ranking in terms of acceptance, usability and security for all proposed tools. Users can contribute to this process by ranking the tool they used. This meant that the 'IT and AI implications' element of LIVE IT – and Task 2.3 - was significantly 'reined in' from its original over-ambitious aspirations to firstly provide a much simpler practical tool to support the use of the Open Toolkit and, secondly, to provide a brief speculative comment on the future potential of AI and machine learning going forward beyond the life cycle of LIVE IT. This latter objective is covered below.

In addition to the Advisor Tool, we also produced a set of 'Lab Packs' to support the collection of data from experiments implemented in future co-Labs and Hackathons. These are intended to illustrate an alternative, more traditional way of mapping tool use against challenges than the AI/machine learning route – as recommended by the project reviewers. The Lab Packs provide guidelines, procedures, templates and resources to enable anyone interested in running participatory co-design experiments with digital tools - and involving people who routinely experience access challenges as co-creators – like people with cognitive disabilities – to successfully implement co-creation activities. In particular they are designed to facilitate the

collection and analysis of key data on tool usage behaviours, mapped against the specific accessibility challenges people with cognitive disabilities face in using digital tools – thereby applying comparable techniques to those envisaged in LIVE IT's original idea of using AI and machine-learning tools, but in a simpler, more practical way. Twelve Lab Packs have been produced, corresponding to the key challenges explored in the co-labs. They are provided in Annex I.

3 OVERVIEW OF THE AI AND MACHINE LEARNING LITERATURE

AI is a promising but also very complex technology with applications in a variety of domains. Developing any AI project requires, among other things, expertise in AI, expertise in the field of application and data.

Beside the need for experts, AI requires great computational power due to complex algorithms that process big data. Furthermore, a substantial amount of time is needed for the AI to train and give feasible and worth counting results.

AI combines smart machines and / or algorithms for processing cognitive tasks that are made by humans. AI can incorporate a variety of technologies to reach this purpose, which can mimic humans and use logic to complete a variety of humans' cognitive capabilities. When referring to people with cognitive disabilities, also referred as intellectual disabilities, scientists are referring to people who have greater difficulty with cognitive tasks than the average. AI technologies can be used as additional aid for PwCD within a wide range of age and diagnosis who face a variety of cognitive deteriorations expanding from learning disabilities, neurological-cognitive impairments like visual disabilities, to dementia (Kharbat et al., 2020; Morrison et. al, 2017; Pollack, 2005). PwCD today experience a significant deal of discrimination. AI technology may offer opportunities to expand virtual and physical access to PwCD, however, a significant part of accomplishing these opportunities is ensuring that AI technology facilitates people with a wide range of abilities (Park et al., 2021). It has been found that, non-AI solutions in many existing situations are already discriminatory and introducing AI has a risk of perpetuating and replicating these flaws (Trewin et al., 2019). There are plenty of researchers who attempt to overcome AI deteriorations.

Sharma and colleagues (2020) developed a six-sense multi-platform app aiming to facilitate people with lack of speech, lack of hearing, visually impaired, visual agnosia, as well as people who are suffering from autism - people with great difficulty in communicating and forming relationships with others. Their product is on two platforms, mobile and web app. Their main implementation is related to object recognition (only for the mobile app) as well as text to speech (T2S) and speech to text (S2T) converter. The S2T and T2S converter utilized the Web Speech API for the website and T2S and S2T library for the mobile platform. Their main highlight was an application that can provide a one-stop-shop solution to all the sections of PwCD. With this app, the user interferes and experiences the initial setup only. There is no need for extra hardware. The use of the service

is free. However, the application depends on the camera picture quality hence, there is a need for better accuracy.
Researchers envisioned an online infrastructure that can enable large-scale, remote data contributions from disability communities. After investigation, they outlined design guidelines for developers creating online infrastructures for gathering data from people with disabilities (Park et al., 2021). Additional research outlined the importance of XAI that aims at making state of the art opaque models more transparent and defends AI-based outcomes endorsed with a rational explanation, i.e., an explanation that has as target the non-technical users (Díaz-Rodríguez & Pisoni, 2020). In addition, further research has been made on two application areas for AI / Ml systems regarding XAI, aging-in-place and mental health support, outlining the importance of nexus between explainability and accessibility (Wolf & Ringland, 2020).
A recent review on new assistive technologies in dementia and MCI care, found that legal issues in the form of workplace safety laws, data privacy laws and regulations, and health care ethics are major barriers to implementation that need to be resolved. As a matter of fact, a new purpose for AI systems may be able to advance what they are able to perceive and help uncover new knowledge and management options for dementia and MCI (Lee-Cheong, Amanullah, & Jardine, 2022).
The field of AI for PwCD remain very promising for future research. However, when creating AI to facilitate PwCD, developers should consider a disabled person user approach and any AI system should be designed to consider PwCD as a focal point (Trewin et al., 2019). The LIVE IT project, incorporated in an Open Toolkit that is used both from the pc / laptop and mobile devices, all the assistive AI technologies and in specific applications that can improve web accessibility for PwCD. Through co-creation sessions and workshops with PwCD and their caregivers / relatives, personal interviews with PwCD as well as Hackathons with researchers, developers, and other specialists, LIVE IT aimed to provide the community with a platform that combines the perspectives of both the technicians and PwCD and caregivers, however with an emphasis in PwCDs' opinion and experience.
In that scope, the LIVE IT project, can benefit from several possibilities of application of AI to improve web accessibility for PwCD. This has also been mentioned in the initial proposal.

4 THE ISSUES WITH PWCD AND THE LIVE IT PROJECT

Today, multiple tools exist to assist users and in particular PwCD in overcoming difficult challenges such as remembering passwords, dealing with foreign languages or being unable to read and write. For a given challenge we can list a set of tools which may help with such a challenge. This was the main challenge of the LIVE IT project. Theoretically, AI could help scaling up such recommendations to a degree where one could tell which tool is most effective to which specific user.

In real life, the LIVE IT team begun evaluating scenarios and corresponding tools with conventional assessments like co-creation lab sessions and Hackathons. Our team then tried to feed all this outcome data to a preliminary AI implementation to figure out whether the results between dealing with real people and dealing with AI match and in what degree.
However, several challenges exist: the system needs to identify what the challenge is, what the user difficulties are, and, for the given user, determine the best performing tool.
To train such an AI system, besides significant expertise in the domain, the project would require at least supporting (robust) big data, i.e., for each tool, how it performs with different challenges, for a given user whose specific cognitive disabilities, difficulties and other relevant attributes are registered in a structured way. The hyper dimensionality of the domain, considering the number of variables (cognitive disabilities, challenges, tools, performance metrics, tasks, etc), points to the idea that, for training such a system, one would require very large amounts of structured data collection which could not be extracted in the required manner from this project, which is in its nature, a pilot project with a limited number of experimental activities.
Furthermore, to acquire such data, the consortium would first need to develop the supporting tools from scratch and determine relevant metrics which allow measuring each variable. While LIVE IT, as a pilot project has its limitations in scale, it shows promising perspectives for a future application of data science and AI project in this domain.

4.1 DEVELOPER AND WEB-DESIGN CHALLENGES AND RECOMMENDATIONS

4.1.1 Summary

The most useful aspects of the LIVE IT project for designers and developers are likely the websites housing all of the hackathon (end-users) presentations, the catalogue of relevant studies, papers, guidelines and other useful resources on creating accessible contents and the developers' tools found in the Advisor tool of the Open Toolkit. The hackathon presentations include the dreams, recommendations, and proposed web accessibility solutions developed by people with cognitive disabilities. This website was created by one of the UK co-lab and hackathons' participants, Julia. To view the hackathon presentations, follow this **link**. The catalogue of valuable useful resources can be found under the LIVE IT Open Toolkit Catalogue tab, found in this **link**.

4.1.2 Catalogue resources

The latter link directs to the Open Toolkit of the LIVE IT project, which includes the Catalogue tab. There, a list of resources is presented relevant to creating accessible content: 46 studies, 9 guidelines, 8 policies, 44 grey literature and 206 other useful resources documents (consisting of 10 COVID-19, 10 policy-related, 14 studies, 28 studies on specific tools, 31 guidelines, 26 good practices, 15 PwCD focusing, 23 developers and content designer / creators focusing, 22 experts and researchers focusing and 27 educators and caregivers focusing documents). Furtherly, additional

resources were added to the existing ones to the Open Toolkit Catalogue during the post-project period, which are more developers' and designers' focused resources and can be categorised and presented as follows:

Subcategory: Creating Accessible PDFs

Theme: Adobe / Target Population: Designers and developers
Link to an Adobe resource , Link to a "Knowledge Base" resource , Link to a "Highline" resource , Link to a YouTube resource , Link to a YouTube resource

Theme: Word / Target Population: Designers and developers
Link to a Microsoft resource , Link to a "Framingham" resource , Link to a Microsoft resource , Link to a Webaim resource , Link to a YouTube resource , Link to a YouTube resource

Theme: Google / Target Population: Designers and developers
Link to a Google support resource , Link to a Michigan Tech resource ,
Link to a Michigan State University resource , Link to a YouTube resource

Theme: Tables & Excel / Target Population: Designers and developers
Link to a W3 resource , Link to a Mozilla developers' resource ,
Link to a University of Minnesota resource , Link to a Wales' government resource ,
Link to a Microsoft resource , Link to a YouTube resource , Link to a YouTube resource

Theme: Other / Target Population: Designers and developers
Link to an "AHEAD Ireland" resource , Link to a regional government services resource

Subcategory: Accessibility of Virtual Reality

Target Population: Designers and developers
Link to a Google Scholar resource , Link to a W3 resource , Link to a UXdesign resource ,
Link to a YouTube resource , Link to a Bureau of Internet Accessibility resource

Subcategory: Translation and Language

Target Population: Designers and developers
Link to a Google Scholar resource , Link to a European Commission accessibility resource ,
Link to a W3 resource , Link to a "247 Accessible documents" resource ,
Link to a Bureau of Internet Accessibility resource , Link to a "Tech crunch" resource ,
Link to a YouTube resource

Subcategory: Chatbots, Avatars, and Online Support

Theme: Chatbots / Target Population: Designers and developers
Link to a Google Scholar resource , Link to an "Orange digital accessibility" resource ,
Link to a Bureau of Internet Accessibility resource , Link to a blog accessibility resource ,
Link to a W3 resource , Link to a UXdesign resource

Theme: Avatars / Target Population: Designers and developers
Link to a Google Scholar resource , Link to an "ACM digital library" resource ,
Link to a "HAL Open science" resource , Link to an accessibility related paper resource

Theme: Online Support
Link to an "Accessibility.com" resource , Link to a W3 resource ,
Link to a "Centre for Civil Design" resource

Subcategory: Other

Target Population: Designers and developers
Link to a "web dev" resource , Link to a University of Minnesota resource ,
Link to a European Commission accessibility resource ,
Link to a universal design (Ireland) resource , Link to a W3 resource

4.1.3 Advisor tool additions

The Open Toolkit has a main output regarding the end-users' interest the Advisor Tool, a tool that enlists assets and applications towards accessibility. Apart from these tools, though, the LIVE IT team has enlisted tools for developers and web content designers and creators. Such tools can be used by all users to create digital contents, are populated in the Open Toolkit Advisor tool and are presented here in alphabetical order: Adobe Dreamweaver, Axe plugin, Bubble, Buildfire, Canva, Coolors, Corel Website Creator, Figma, Glide, Google Web Designer, Hootsuite, HTML Kit , Landbot, Magisto Magisto, Mail Chimp, Makerpad , Monday Marketer, Movavi Video Suite, NoCodeHQ, ObviouslyAI, OpenElement, Planable, RapidWeaver, Sheet2Site, Shopify, Site 123, Sketch, Slickplan Website Content Planner, Square Space, Survey Monkey, Triggre, Universe, Webflow, Weebly, Wix and Zapier.

4.1.4 Recommendations

Designers: The scenarios envisaged during the LIVE IT project focus on situations that can currently be considered to be substantially rather rare. As a consequence, they are usually treated

as marginal when designers approach issues of mainstream usability. This is a self-perpetuating problem, however, in that their relevance to mainstream projects is dangerously underestimated in everyday design and implementation work, not only in the field of the relationship between people with cognitive disabilities and online media, but across the board, in the field of how people with any form of disability, whether physical or cognitive, relate to the artificial environment in which we all live to a greater or lesser extent.
The recommendation offered to practising designers in the light of the many years of experience of Design for All (represented by its ambassador Pete Kercher who was a subcontractor of LIVE IT) is that they study these scenarios with care, so as to employ the lessons that can be learned from them as extreme-case situations, whose inclusion in a mainstream design process is posited as the litmus test for true inclusion.
Rather than merely copying these scenarios, however, designers are invited to embark on a coherent process of user involvement, in accordance with the methodology of Design for All, as quoted in the Stockholm Declaration (**link**), which states that "Design for All is design for human diversity, social inclusion and equality", then goes on to expound on the methodology with these words: "The practice of Design for All makes conscious use of the analysis of human needs and aspirations and requires the involvement of end users at every stage in the design process". This entails not only analysis, but a constant iterative process of consultation with those users who experience the most challenging situations in their interaction with the objective of the design process, since the ability to include such cases has been found to generate results that are also convenient, easier to use and thus beneficial to all mainstream users.

Developers: Every design process is a multifaceted partnership: while the designer acts as the leader of the process, the figure of designer should never be considered to be the sole figure of relevance. Just as an automobile designer would remain a theorist in the absence of the engineers who lend their expertise to translate the draft design into functioning models of good engineering, so a software designer must work in partnership with software developers and web designers must involve not only the end users mentioned in the previous section, but also the developers who work behind the scenes to codify the instructions elaborated by the designers.
Once again, the accent here is on conveying also to developers the important message that the scenarios experienced in the – albeit short – lifetime of the LIVE IT project are of vital interest when applied in a sense that is not sectoral, so does not focus solely on the specific user groups in question, important though their needs are, but mainstream in nature, in compliance also with the principles of Design for All.

The accessibility recommendations to be applied while these two partners create digital projects are aggregated in the following list:

- Maintain clear contents, use simple layouts, leave spaces between elements, use not much text, try to include visual or audio supporting
- Consider people that do not speak English, but either way use always plain language

- Ensure ease of navigation / guide users to what is the required action from them and what they should do / how they should act
- Tools should be accessible from start to finish, meaning that the installation process and optimization / setting procedures should also be accessible
- Create free tools, ad-free, accessibility should not facilitate only people able to pay – including updates
- Ensure dictation is working, especially with people not being able to pronounce / articulate perfectly
- Create tools to facilitate interpretation and processing numerical information, dates, tables, calculation and other complex forms of content
- Create tools that are easy to use / easy to follow – direct users to next steps
- Create a cross-platform button that enables text-to-speech or dictation features
- Create tools that can generate abstracts from long dense contents
- Create tools that can read lips to facilitate direct conversations
- Create tools that blur background to help users focus on text reading
- Create tools that provide the feature of profile setting according to challenges or per diagnosis and customise all digital content according to profile selected
- Create tools that can remove, blur, or hide media such as pictures, ads, videos or animations
- Create tools to facilitate PDF accessibility and compliance to standards and protocols
- Create a virtual assistant that can be adjusted based upon different diagnoses, for example when a user faces memory challenges, the virtual assistant could be used as a reminder, when there are reading problems, the virtual assistant could easily read content on screen by just pressing a button
- Create tools with no errors, bugs – it confuses PwCD more and makes them feel responsible for the error
- Too many options and elements may as well be confusing, especially when not presented simply
- Integrate visual / layout tools with text-to-speech tools to motivate users to read along readers
- Make tools compatible with most browsers / operating systems
- Readers' speed should be adjustable when not already
- Readers should use more human voices and not robotic digital voices
- Text-to-speech tools should integrate translation mode for live translations
- Use audio / visual elements and instructions to support text-based content
- Use chatbots or helpdesk and FAQ whenever possible
- The harder the disability, the harder the solution needed, nevertheless it should be aimed
- Digital skills acquisition is important for caregivers that often act as mediators / training delivery provision to caregivers, but also offering of know-hows and tutorials to end-users

- PwCD are still dependent to their caregivers to interact with existing tools but that should change - self-esteem, independency and privacy issues are caused by the required constant presence of mediators to digital interactions
- The digital world must move towards an environment where accessibility tools would be pointless and useless – the digital world should be accessible without tools and assistants.

4.2 END-USERS' CHALLENGES DURING USE OF ASSISTIVE TOOLS

4.2.1 Summary

During co-labs, people experimented with tools to tackle their daily digital challenges, but even so could not interact successfully with the digital world. This section aims to present relevant data and analysis regarding instances and participants that were unable to use accessibility tools directly and did not engage successfully with scenarios' work in the way that was originally planned.

It was frequently impossible to carry out formal co-lab tools work without a period of acquaintance and trust building. introducing the LIVE IT project and its aims and gauging the reality of both cognitive challenges and difficulties as well as participants familiarity and capabilities with both devices and websites. In some cases, we had to move away from the idea of scenarios and formal accessibility tools work when this proved excessively challenging for participants. In these cases, we worked with participants to find out the ways in which participants use websites and devices in their everyday lives, if at all. Whether they could read and what other key challenges they experience with both on-line content and with technology in their lives. Many participants found a formal assessment of accessibility tools too complex and demanding due to a combination of factors including short attention spans, anxiety associated with technology usage and text-based websites, difficulties using new accessibility applications, reading problems and very low technological skills, coupled with the abstraction of working with emergency scenarios.

Many of the participants we were working with had complex and significant challenges, sometimes with additional life challenges related to low income and poor support opportunities – especially in UK co-labs. Many had experienced layers of exclusion in their lives, coupled with concurrent and related mental health, and other serious existential challenges such as isolation and housing need to name but a few.

We were in theory working with four theme scenarios. This was most challenging in the UK co-labs, where the theme was 'emergency' and which was possible to do this with a few 'technologically skilled' individuals. Many others had to be coaxed and the idea of emergencies or

urgent need explored in the context of web-accessibility and technology. For many ‘emergency scenarios’ was too abstract and unhelpful in terms of exploring whether and how they used the ‘web’ and ‘websites’ at all.

For participants, the abstract nature of digital terms and interactions required the imagination of scenarios, such as, 'what if this or that occurred or somebody in your family/group was ill, had an accident, there was a fire etc.’. We had to gauge this carefully and consult with carers in order to work out what could be explored in individual cases. Many of our participants avoided standard websites and technology for a range of reasons, preferring human interaction and support, audio-visual technology (largely on smart-phones) and website usage such as; YouTube, Tik-Tok, TV, Instagram and similar, facetime and video calling applications, for news and information. We saw a wide range of differing and complex combinations of cognitive challenges, coupled with other personal challenges that frequently relate to mental health and feelings of exclusion or worthiness in participants. Particularly when trying to direct non-readers towards text-based websites, information and digital tools or accessibility applications and tools. Significant anxiety arose with a number of participants in relation to the LIVE IT co-lab work. Additionally, a large percentage of those involved in the South London lab were non-readers, or had significant reading challenges, coupled with very low or non-existent device and IT skills.

Most of participating users did use phones, tablets and the web, frequently in very specific and limited ways that they were familiar with (YouTube or on-line jigsaws for example in one case). Some did not have access at all (internet or suitable technology) except in open access community centres or similar with facilities for IT access. An across consortium observation also was that users depend on a high level to relatives or carers to successfully interact with the digital world.

The message that came across was that every case was complex and individual. Skills support, device optimisation and training are a need. For many the existing ‘web’ is not ‘designed for us’ and does not take the complex range of neurodiverse challenges and needs into account. Fully customisable and simple sites or site versions are necessary, with suitable signposting, alternative text and images and more curated audio-visual alternatives for many, especially those with reading challenges. There were a surprisingly high number of participants that had significant reading challenges or could not read effectively at all – this problem becomes of utmost importance considering that non-English speaking people face ‘dual exclusion’ and cannot benefit from most assisting tools that use English language. Some participants had technology such as laptops, tablets or smart phones that they could not use.

The communities and people that LIVE IT worked with were characterised by significant needs and challenges, with generally poor or medium personal resources and skills. During the course of the

LIVE IT co-lab work, it was quite shocking to discover how many of our cohort could not read without help or were unable to carry out the most basic functions on web access devices such as smart-phones, tablets, PCs and laptops. It should also be noted that this was all taking place in community spaces, schools and consortium premises with participants taking part on a voluntary basis, often in venues that they wanted to use for primarily social face to face activities, personal support and fun. Despite the earlier assertion that there was strong interest, which was true in the sense that participants wanted better accessibility and 'a web that is designed for us', this was never something that LIVE IT could provide in the project's lifetime. Participants were keen to be involved in improving web accessibility through consultation and experimentation.

Participation in LIVE IT co-lab sessions was challenging and difficult for most of our participants with significant issues, and impossible directly for some. Anxiety causing also for some of our participants where attention and span, dealing with text and symbols, reading, typing or navigating on-line, screen appearance and other difficulties, including keyboard or button usage, were significant.

Other key issues of note should also be pointed out before presenting a breakdown of the challenges and reasons for difficulty that were experienced with participants and the 'testing' of accessibility apps model that the LIVE IT Project's co-lab model was using.
The scenarios intended for the co-labs proved somewhat unhelpful in some cases. Participants had very limited interest in the internet and on-line information relating to emergencies in the case of those with the most significant challenges. Those with significant reading challenges or aversion to text-based sites stated that they would seek real life help or reach for a phone to call a trusted support person. Although there were also many participants that engaged, mainly those with a reasonable level of IT and reading skills.

Interestingly, one Downs Syndrome participant, who was making progress with learning to read, learnt also from TV shows (and Fairy Tales), he had watched on-line using YouTube or on TV. He was able to talk about strategies such as "get down, get down" referring to what you have to do in a fire if there is smoke build up. This was something he had picked up from a police drama series. A decision was made with his carer to not engage with text to speech applications, as it could potentially interfere with the progress he was making with reading and writing. He was unable to engage with the app trial approach at all but was enthusiastic and informative showing us what he could do on a laptop. He was introduced to the idea of voice search in YouTube, and predictive text in searches.

Those with some IT skills who found text problematic (ASD and Dyslexic participants on the whole, with additional issues such as ADHD, Brain Injury and a myriad of Cognitive Disabilities simply

labelled using an umbrella term as 'Learning Disabilities') were drawn to and preferred audio-visual and social media sites such as YouTube, Instagram and TikTok for information. In most cases participants exhibited variable awareness of the difficulties that these sites present in terms of reliable and trusted information sources.

This observation was made across all co-labs – participants preferred audio-visual information and scenarios including such interactions were easier to implement than tasks involving only or mainly text interactions.

4.2.2 Aversion, Anxiety and Reading Difficulty

Many of our participants found engagement with the technology in use, accessibility apps and the co-lab model of questions and site navigation, challenging or impossible, or anxiety causing, frequently both. Many lost focus very quickly, were unable to do things like find, download and install apps for themselves, so had very limited interest in or understanding of what we were doing in terms of trialling and evaluating accessibility tools. Based upon that, a revised version of scenarios was applied in such instances, to draw attention, raise engagement levels and steer the scenario towards the participants' likes and preferences.
There was strong interest from many participants in the idea of improved web access and an internet they could use. In the vast majority of cases in order to maintain some engagement, researchers had to introduce the concepts and then find out what participants could or did do online, and with what tech and apps. In many cases individuals were reluctant or refused to re-engage after an initial introductory session with comments like "the questions they are so long", "it's so hard", "I wouldn't do that", or of course "I can't read", a qualification that most participants hid from the world or were extremely reluctant to admit to or verbalise, except to a trusted few. Although, participants experimenting with text-to-speech tools and speech-to-text tools managed to successfully implement the initial scenarios (Ireland and Portugal co-labs examples), while revised versions were required only for scenarios involving composing and writing (Irish co-lab example).

Rather than attempt to coerce participation according to our co-lab accessibility applications testing model, researchers guided challenged individuals through some limited web access and accessibility options, and recorded participants thoughts on skills, wants, needs, interests and challenges in terms of device usage and web-accessibility. In many cases this amounted to providing very basic IT skills and device optimisation help. There was most interest in built in free accessibility applications in Android and Apple IOS phones and tablets, as well as Windows, Google

and Apple IOS built in accessibility features for devices including laptop PCs. Often screen reading and voice control applications were of significant interest.

The researchers engaged with individuals and support organisations, many participants were already known to the researchers and/or participating organisations. Post COVID-19 lockdown periods (and during, when support organisations were permitted to meet) there was a hunger for face-to-face social interaction, as all of our participants had been horribly isolated and also experienced significant social exclusion as a matter of course due to their 'differences' from neurotypical people. These difficulties were amplified by a lack of access, skills and on-line services that worked for them, in a period where the whole world went on-line only, excepting those excluded from internet and on-line access due to the challenges and reasons listed above.

As a result, there was strong initial interest, followed by withdrawal in some cases, when prospective participants realised how challenging LIVE IT co-lab work was for them. What they really wanted and needed was social interaction and inclusion, rather than more technological interaction. It is also important to note that in some cases participants were publicly sensitive about their 'disability/ies', showed reticence about allowing others to know they had difficulties at all, or the extent of those difficulties. A number of our participants also reported on how poorly they had been supported in school (except to special schools) and by social and other institutional services.

A particularly illuminating case involved two female participants in their mid-teens and early twenties with ASD who were really expressive in terms of what they did on-line and why over the course of several co-lab sessions. These participants were sisters, with a good support network, both were very able and had IT-skills, but had significant aversion to text and text-based sites due to their ASD. The usual text-based websites were invariably anxiety causing and required significant accessibility help in order to be useful (mind-maps, filters and overlays, breaking text down into blocks and simplifying, noting key point summaries for dense information in text form). Both invariably preferred and used image, audio and video based social media sites preferably, that used simple captions. These included, TikTok and Instagram in particular. The elder of the two (15yrs and 21yrs), a single parent with an under 5-year-old son, engaged over a period of several months and in several short sessions quietly elucidating the challenges and solutions she had implemented, and why the LIVE IT model was not of significant interest to her.

An illustrative excerpt from field-notes that may be illuminating:

“A realisation following another session with L... who is on the autistic spectrum yesterday, bright as a button. She's been saying from the start that she avoids text-based sites, lists, questionnaires and many layouts. Too much text does all sorts of weird things to her head and vision, the implied stresses at college led to a breakdown of sorts. She was really eloquent again (We've had several informal sessions with her and her sister) and making a point.

What she and others have been saying is that what works best for her is image, video and audio. And here we are still trying to get her to try things she's no desire or interest in using. She was coming up with all of the really valid reasons why not to, or why she doesn’t use a particular tool or type of website (in terms of her cognition differences and needs). It's incredibly individual, but a large number of our ASD South London participants similarly avoid text-based sites in this way.

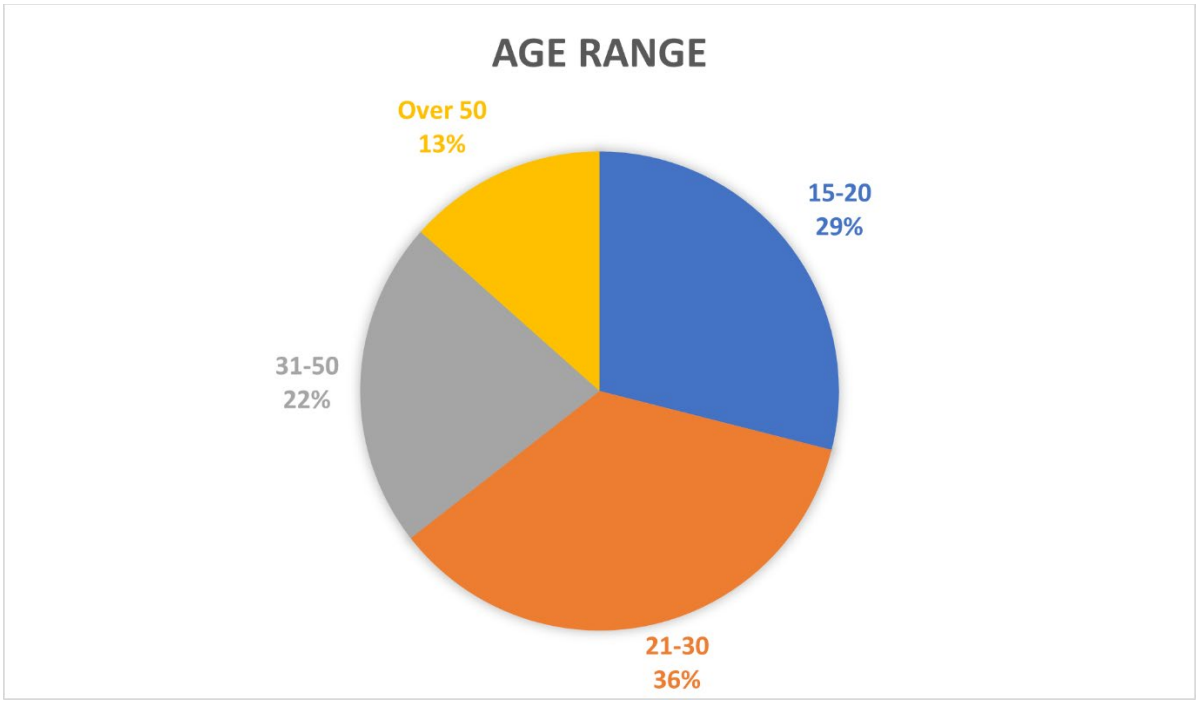
What sessions with L and others seem to suggest is that if anyone is really serious about digital inclusion and people like L..., then rather than try and turn her into something she can't or struggles to be, we should listen to what she's saying and provide simplified accessible and signposted alternatives. i.e., video and audio versions or links to animated and video information casts etc.

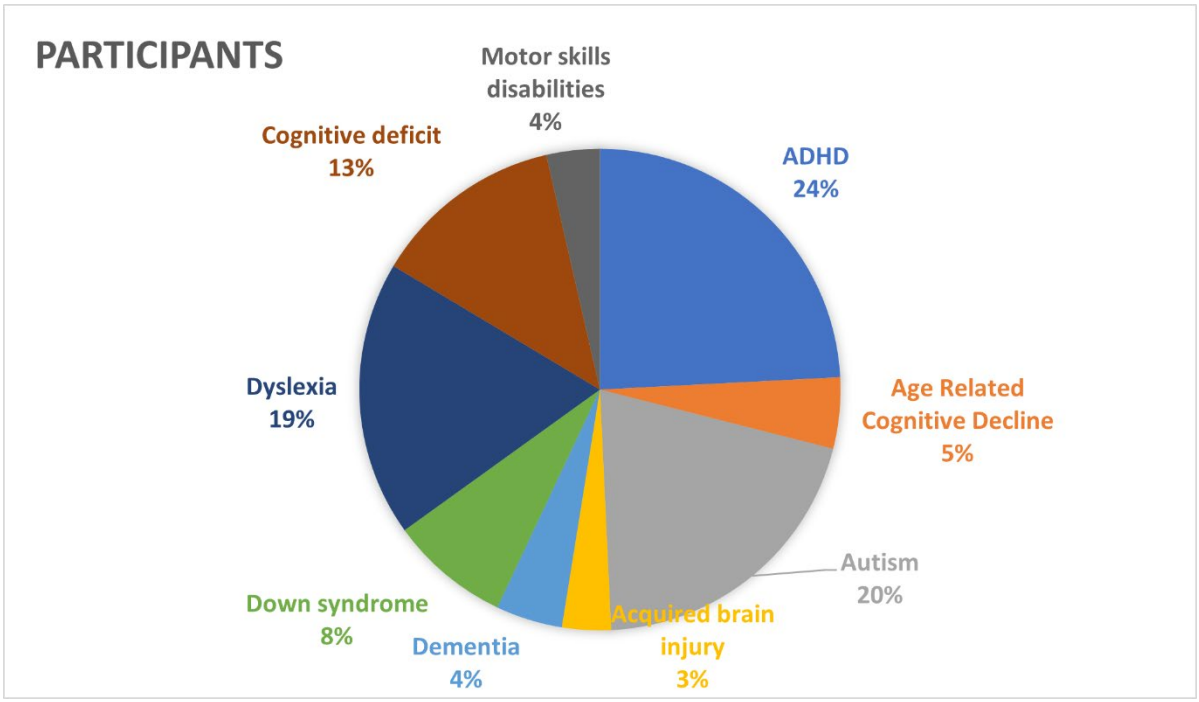
Of course, she knew that all along, and that's why she's kept telling us what you can do with Tok-Tok, Snapchat, Instagram, and YouTube. Whilst also raising concern about 'fake news', disinformation and online bullying, mental health concerns and ChildLine as examples of things that matter to her.

She'll preferentially reach for a phone, facetime or a person she trusts as soon as she can, because she's learnt that that works, whilst others are trying to make her fit their boxes and do her things their way! And I realised that that was what we were doing with her too, and she was genuinely taking us at face value and trying to educate us it seems on reflection on what needs to change."

4.2.3 Analysis

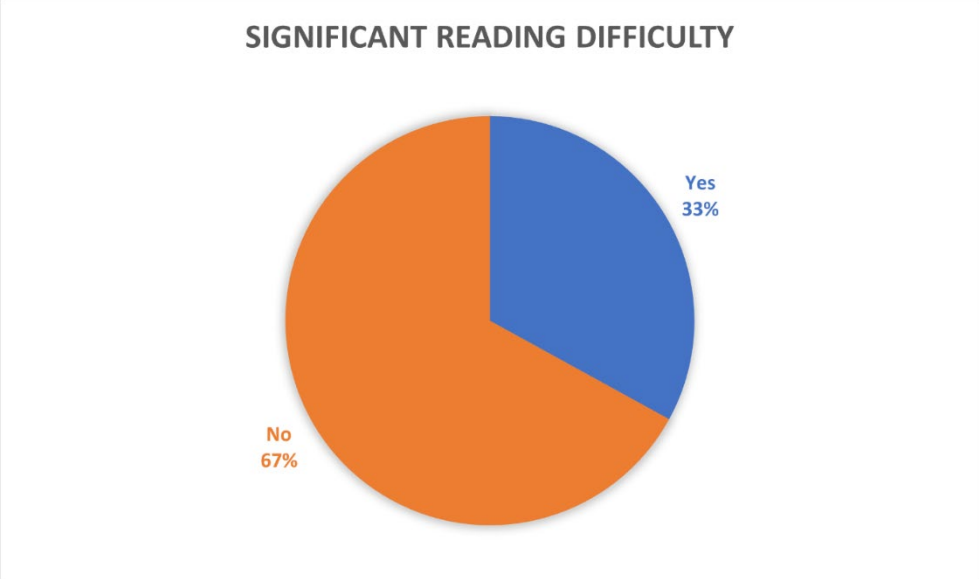
Using the most comprehensive data we have on twenty-one of the London co-lab participants a partial picture may be presented. Below are graphs of all the variables that were recorded, cross tabulating the ability to use tools against the other variables.


AGE RANGE
Over 50
13%
15-20
29%
31-50
22%
21-30
36%


PARTICIPANTS
Motor skills disabilities
4%
Cognitive deficit
13%
ADHD
24%
Dyslexia
19%
Age Related Cognitive Decline
5%
Autism
20%
Down syndrome
8%
Dementia
4%
Acquired brain injury
3%

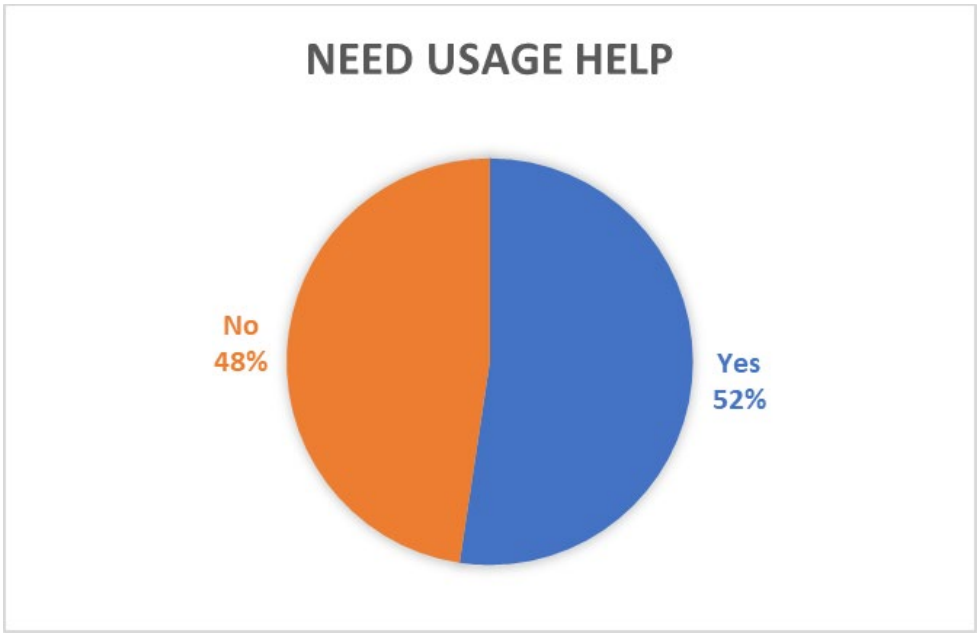
4.2.4 Reading ability

Perhaps the biggest challenge experienced was the reading ability of participants. Two thirds of co-labs participants were able to read well enough to deal with tools usage and text-based websites effectively without significant help, when in nature language, although the interaction with global websites and digital world, or provided accessibility tools was compromised by the lack of versions for non-English speaking users – an issue that could be regarded as indirect reading inability.

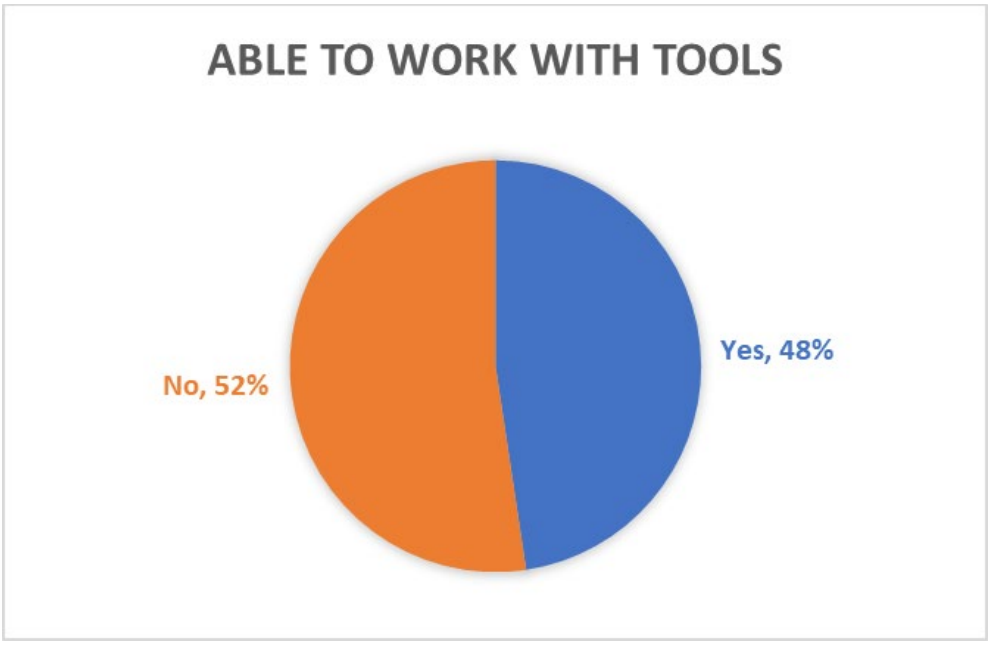


4.2.5 Devices, skills and tools usage help

Nearly half of our participants needed significant help with device usage and tools had to be demonstrated for them rather than used independently. Effectively co-lab sessions with these participants became device optimisation and a demonstration of possibilities, with limited participant tools usage:

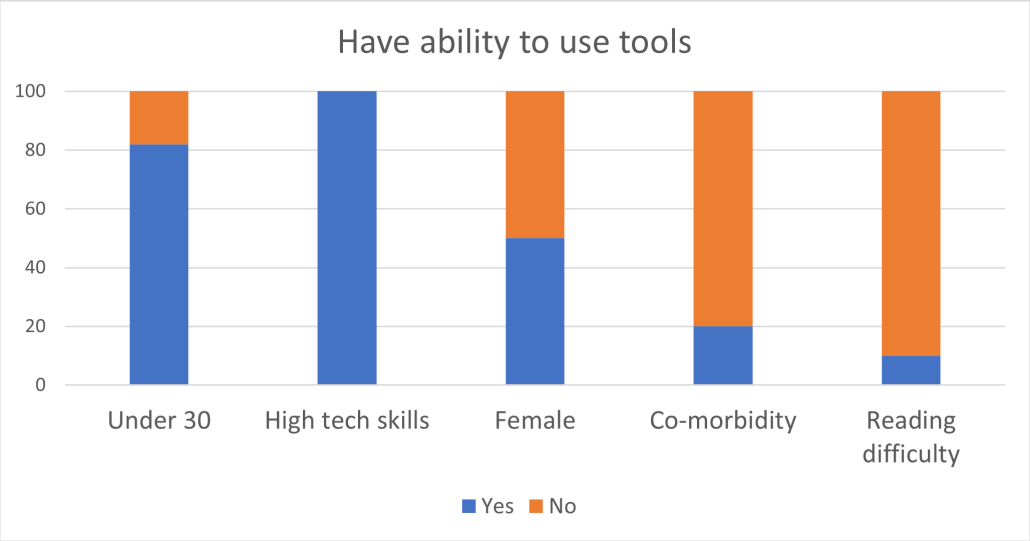


Slightly less than half of our participants were able to work with tools in our co-lab scenarios exploration as indicated below:



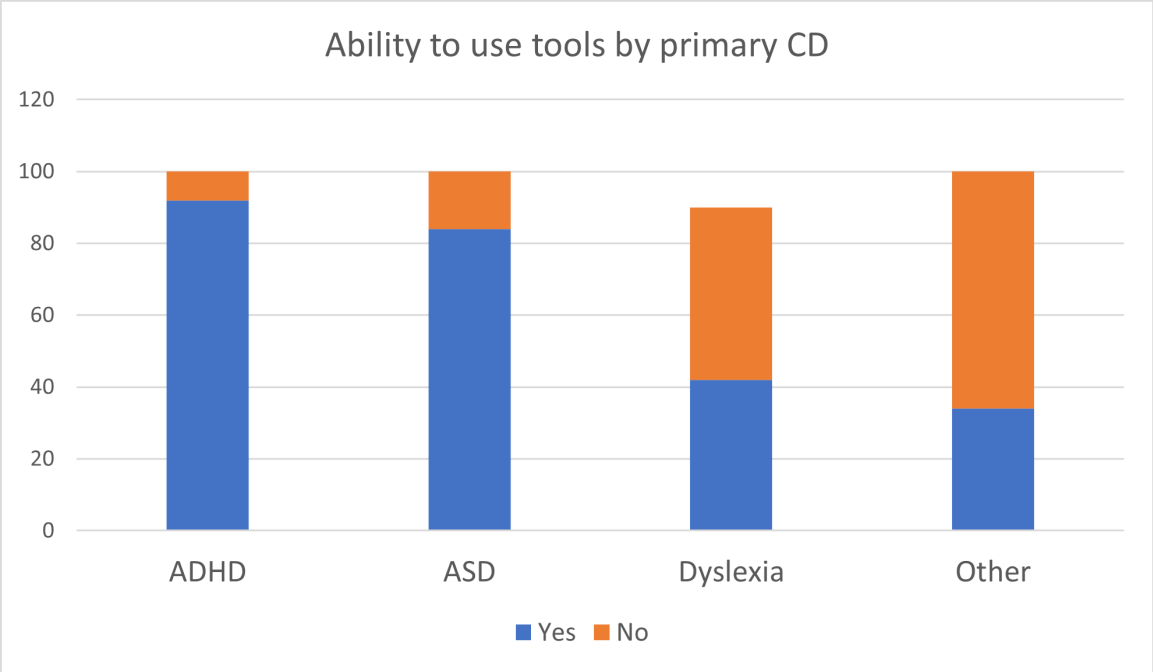
4.2.6 Correlating challenge factors

Correlating the various factors at play, we find the following in terms of ability to work with tools directly in some fashion in our co-lab scenarios or web usage explorations:



As shown in the graph, participants who were able to use the tools effectively were:

- Younger (80% below the age of 30)
- More technically highly skilled (100% level 4 and 5)
- Both female and male participants
- Less likely to present with a cognitive co-morbidity (20% with co-morbidity)
- Less likely to present with reading difficulty (10%).



As the above graph shows, an association was found between primary cognitive disability presented and ability to use tools effectively. Participants with dyslexia were less likely to use tools effectively. Participants with ADHD and ASD were more likely to use tools effectively at least for some time.

4.2.7 Conclusions

There was a combination of factors in play that prevented meaningful engagement with the accessibility tools trial approach in the LIVE IT co-labs for a significant percentage (52%) of participants. These involved a combination of challenges including most importantly:

1. Significant reading and other skills challenges
2. Significantly low levels of technological skills, coupled with access difficulties and economic hardship
3. Very short attention spans or other behavioural challenges that made understanding and extended session work problematic
4. Aversion and an experience of failure with reading and text-based websites in the past.

It appears that reading ability was a significant factor, but that ability to use tools is shaped by all factors. What was clear in delivery was that device optimisation and technological support is a significant need, in addition to more inclusive web-design, and individually customisable accessibility tools considering that the information contents should be successfully transmitted to the end-user to fully activate and engage in a digital accessible daily experience. This information includes navigating digital contents, finding what is needed, understanding the process required to act upon, act freely and independently upon it, using tools and services, reaching out, sharing experiences and connecting with the parallel digital world.

5 THE LIVE IT TOOLS' MAPPING TO CHALLENGES

As already mentioned, no AI technology was developed in the context of the LIVE IT project due to various factors. After discussions conducted in the interim review with the reviewers, it seemed that the most valuable and efficient way to proceed was, based also on reviewers' opinion, to put more effort on feasible outputs. Nevertheless, the consortium should find a way to substitute the AI actions with non-digital mapping of challenges to tools. Therefore, the LIVE IT team implemented scenarios planning, co-creation labs activities with observation sessions and relevant discussions with end-users to facilitate the mapping of the created tools' list to the challenges' list identified. This was an extensive and comprehensive procedure that led to cross-referencing the current tools' list added in the Advisor Tool to the current challenges identified. As a result, the LIVE IT offers a set of tools that help to address challenges users can choose. The mapping of tools to challenges is updated during the post-project phase (some tools were irrelevant and falsely categorised and are now fixed, while new tools – especially web authoring and content creation tool – are included and are presented below in Table 1 and also shows the number of tools mapped to each challenge or category.

Table 1 - Tools' mapping to challenges

TOOLS' MAPPING TO CHALLENGES		
Category	**Sub-categories**	**Amount**
Memory	Difficulty recalling sign in information such as passwords	***4***
	Difficulty recalling personal and family information	***26***
	Difficulty to remember which button to press each time	***4***
	Difficulty remembering the steps taken in a calculation when they are not shown on the screen	***4***
	Difficulty remembering processes	***26***
n=136	Difficulty remembering appointments and important tasks	***21***
	Difficulty retaining information	***40***

Focus	Difficulty staying focused	***14***
	Cognitive overload in the presence of complex interfaces or too much information	***22***
	Cognitive overload from pop ups and other distractions	***8***
	Delayed processing: additional time required to take in and understand information	***14***
n=115	Difficulty understanding abstract concepts such as the internet and its navigation	***8***
	Difficulty communicating with people when they are not visible/there is no face-to-face contact	***5***
	Fatigue	***28***
Time and organisation	Difficulty with time management and organisation	***35***
	Difficulty remembering the date, day or time	***13***
	Difficulty finishing tasks	***30***
	Difficulty sequencing and completing multi step tasks	***32***
	Difficulty understanding time	***9***
	Difficulty planning for the future	***33***
	Difficulty avoiding or managing online distractions such as Netflix or social media	***5***
	Difficulties organising and managing files	***4***
n=214	Starting tasks	***4***
	Organising ideas	***13***
	Managing finances	***5***
	Planning journeys	***3***
	Difficulty prioritising tasks	***1***

Mood	Anxiety and low mood	***20***
	Lack of motivation	***19***
	Feeling isolated	***10***
	Fear of trying new things	***15***
	Difficulty with self-belief and imposter syndrome	***18***
	Difficulty managing emotions	***21***
n=157	Difficulty with handling the unknown or unexpected	***22***
	Need of support in getting things done	***11***
	Feeling overwhelmed	***12***
Physical Barriers	Difficulty in movement and motion for example due to a tremor	***17***
	Difficulty using a touchscreen	***12***
	Difficulty using external hardware/devices	***16***
	Visual impairment	***32***
	Difficulty reading when font is too small	***18***
	Motion sickness and vertigo	***6***
	Difficulty with speech and language	***19***
n=137	Difficulty with spatial navigation and getting lost	***3***
	Risk of falling over	***2***
	Colour blindness	***4***
Reading, Writing and Comprehension	Difficulty reading	***32***
	Difficulty writing	***23***
	Difficulty with spelling	***6***
	Difficulty with punctuation and grammar	***5***
	Difficulty reading and following instructions	***25***
	Difficulty filling out forms	***12***
	Difficulty finding information	***11***
	Difficulty understanding information including long and complicated text	***17***
n=158	Difficulty dealing with text in foreign languages	***1***
	Communicating with others (speech)	***16***
	Difficulty understanding facial expressions	***1***
	Difficulty recognising faces	***2***

Numbers **n=15**	Difficulty understanding numbers and carrying out basic calculations	***6***
	Difficulty using money due to not understanding the value of money	***5***
	Difficulty using bank cards due to not understanding the value of money	***5***
	Difficulty understanding numerical concepts such as 'less than' or 'more than', 'percentages', 'average' and 'difference'	***1***
Digital skills **n=215**	Difficulty navigating the internet	***33***
	Difficulty navigating complex websites	***29***
	Difficulty operating online in unstructured environments such as social media platforms and search engines	***4***
	Need of support in using digital devices	***10***
	Difficulty using keyboards for example due to buttons being too small	***18***
	Difficulty with online learning	***25***
	Difficulty avoiding risks online such as viruses, inappropriate content and cyberbullying	***7***
	Difficulty finding and paying for goods and services	***2***
	Difficulty booking appointments/activities online	***7***
	Difficulty saving specific information in an accessible way	***12***
	Difficulty finding employment opportunities	***5***
	Difficulty working from home	***5***
	PDFs not compatible with T2S tools or screen readers	***13***
	Using device / tool / site more efficiently	***14***
	Help navigating a device	***8***
	Web authoring and content creation	***4***
	Support in an emergency	***6***
	Communicating with others online	***11***
	Looking for employment online	***4***
	Web authoring and content creation	***36***

Developers	Developing and assessing accessible websites	***16***
	Colour identification and contrast	***3***
	Web authoring	***36***
	Supporting understanding of accessibility	***4***
n=31	Biometrics and wearables	***1***
	Tools for co-design	***3***

6 CONCLUSION AND IMPLICATIONS

This Deliverable has presented how Task 2.3 – IT and AI implications – was approached in the project. It highlights the extent to which the original ambitions for Task 2.3 were significantly changed, considering our experiences in working with people with cognitive disabilities as co-designers in the LIVE IT co-labs and Hackathons, and considering the observations and recommendations made by the project external reviewers. A key conclusion of the Deliverable is that, although the use of AI and machine-learning techniques and tools was potentially of significant benefit, we had neither the time, resources nor the in-depth expertise to fully implement the project's original aspirations. As noted in the project 'sustainability plan' – Deliverable 5.3 – we recommend that, based on LIVE IT's research, there are persuasive grounds for expanding LIVE IT from a 'pilot and preparatory action' to a large programme. A key 'action line', were such a programme to be developed, should be devoted to technological research and development. It has become clear that further work needs to be done in exploring the opportunities afforded by AI and machine learning methods and tools to develop web accessibility solutions that are closely attuned to the needs and lived experience of people with cognitive disabilities. As noted above, although this was one of the objectives of LIVE IT, it became clear as the project developed that we had neither the time nor resources needed to explore AI and machine learning capabilities in any depth. In addition, LIVE IT's co-lab experiments and Hackathons have identified a number of promising avenues for AI and machine learning-related technological research and development, for example novel user interfaces that adapt to user behaviours, intelligent tools that learn from user behaviours, guidance and support tools like intelligent 'super chat bots' and virtual personal assistants (VPAs).

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8 ANNEX

Co-creation labs pack

Filename: LABS pack.zip