

The Case for ‘Health-Induced Impairments and Disabilities’

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Figure 1: COPD (Chronic Obstructive Pulmonary Disease) Workshop

ABSTRACT

Health conditions, both chronic and acute, are often accompanied by disability-like impairments that might affect mobility, cognition, or perception. These impairments are often pernicious because they are difficult to isolate, vary in intensity and extent over time, and are under-investigated. Here, we make the case that solutions to these impairments are often impervious to traditional accessibility solutions and thinking, and that new solutions are needed. We present argumentation and case-studies, which build the case for a different category of impairments called ‘Health-Induced Impairments and Disabilities’ (HIID). The distinction between traditionally defined disabilities and HIIDs is essential because an understanding that

this category of impairments is fundamentally different both in cause and nature affects the effectiveness of the accessibility solutions we provide. Here, we intended to outline the ‘problem’¹ space and elaborate on the four main characteristics of HIIDs (as we see them) to provide delineation and clarity. It is the only way we can enact on robust solutions within this problem space, being: (1) Combinatorial Impairments; (2) Dynamic Impairments varying in Magnitude and Extent; (3) Impairments as a Comorbidity; and (4) Socio-Technical. We intend to outline these characteristics with third-party cases to serve as exemplars of the problems faced. We do not provide research solutions, or indeed any novel empirical evidence. Instead, we define a place for discussions to begin. Therefore, this work is better understood as a position paper or a call-to-action. We make the case that addressing the disability (caused by the underlying illness) is often ineffective; what we need to do is address the illness directly which will in turn address the disability through their transitory relationship.

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¹Here we use the term problem and solution purely in the scientific context.

CCS CONCEPTS

• **Human-centered computing** → **Accessibility theory, concepts and paradigms; Accessibility design and evaluation methods**; HCI theory, concepts and models; • **General and reference** → *Computing standards, RFCs and guidelines.*

KEYWORDS

Health, Impairment, Co-Morbidity, Call-to-Action

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1 INTRODUCTION

The concept of 'Health-Induced Impairments and Disabilities' (HIID) is not new; indeed, it was first mentioned as part of the work of Nicolau and Jorge circa 2012/13 [17] when they presented a disability continuum. Informally but in parallel, this concept of the continuum became part of discussions at the W4A Conference Steering Committee around that same time, which directly lead to the changing of its name and tagline away from 'disability' to 'barriers' [6]. These ideas of a continuum (or spectrum [35]) are undoubtedly correct but can also be problematic when trying to define accessibility solutions for groups of individuals as opposed to bespoke solutions for a particular individual (think the JAWS Screen-reader as opposed to a 3D printed prosthetic). Our previous work in Blind Accessibility, Ageing, and Autism coupled with our experiences in Mental Illness, Lung Cancer, Parkinsons Disease, and Neurodegenerative Disease has provided insight into how disability-like impairments manifest in relation to the underlying condition, elucidated how the focus is 'always' on the underlying condition and often not on the symptoms, which might well improve quality of life, and highlighted how, already vulnerable, patients are often disempowered and disenfranchised.

Further, a patient's condition may be both chronic or acute, but an exclusive focus on this condition (while necessary) might ignore accessibility solutions to the accompanying impairment(s). These impairments are often pernicious because they are difficult to isolate and vary in intensity and extent over time. The World Health Organisation (WHO) defines disabilities as:

"The International Classification of Functioning, Disability and Health (ICF) defines disability as an umbrella term for impairments, activity limitations and participation restrictions. Disability is the interaction between individuals with a health condition (e.g. cerebral palsy, Down syndrome and depression) and personal and environmental factors (e.g. negative attitudes, inaccessible transportation and public buildings, and limited social supports)."

We can see from this definition that the health condition 'is' the disability as opposed to an underlying condition that generates the disability. This distinction is crucial because just as with Situationally Induced Impairments and Disabilities (SIID) [31, 32, 34], the understanding that this category of impairments is fundamentally

different both in cause and nature affect the effectiveness of the accessibility solutions we provide.

Our work has enabled us to outline the four main characteristics of HIIDs, which we delineate from the wider body of accessibility research and may provide clarity such that we can enact on robust solutions within this problem space:

- (1) *Combinatorial Impairments*: several low-intensity impairments that, in combination, create significant accessibility barriers in everyday life. For instance, combinatorial impairments are often found, but not limited to, older adults and associated with the natural 'ageing' process. Other examples include Diabetes, which may affect vision and tactile perception.
- (2) *Dynamic impairments varying in Magnitude and Extent*: impairments often vary in the intensity of the experience and its length. These may be related to the nature of the underlying condition (acute or chronic) but are often experienced based on who the underlying condition is manifest at a particular time, treatment of the underlying condition, interrelationships between the condition and other aspects of other physical or mental aspects, and importantly, factor or factors unknown;
- (3) *Impairments as a Comorbidity*: we might see impairments as comorbidities – the presence of one or more additional conditions co-occurring with a primary condition² – in this sense, we might see mobility impairments comorbid with Asthma. By addressing the boundary of Asthma then we may be able to relieve the comorbidity of impaired mobility;
- (4) *Socio-Technical Impairments*: impairments that are societal, economic, or technical have a bearing. These may include factors such as low-income, low literacy, or fear of technology. Addressing these issues may relieve the underlying condition (with better management, say) and thereby alleviate the linked impairment(s).

We intend to outline these characteristics with third-party cases to serve as exemplars of the problems faced. We do not provide research solutions or any novel empirical evidence. Instead, we define a place for discussions to begin. Therefore, this work is better understood as a position paper or a call-to-action.

2 THE ARGUMENT FOR HIIDS

Our prior work has enabled us to assert that HIIDs are a special kind of impairment that cannot be adequately addressed by direct accessibility solutions to the disability that is currently taken to be 'primary'. Here, we see that the health condition is primary, and the impairment is a result of this underlying condition. Further, traditional accessibility thinking may not be beneficial in providing solutions - which instead may need to be created to address the cause of the impairment or the interface between the impairment and the health condition.

Let us consider tremor caused by Parkinson's Disease (PD), which is one of the distinctive signs of PD, and that may generate substantial disability [19]. It is the lack of Dopamine in certain

²For Example, Schizophrenia is often comorbid with depression, anxiety, substance abuse, and other addictions.

connections within the brain that causes such tremor [9, 10]. Treatment to manage the tremors – which is not wholly successful – is through additional Dopamine typically taken in the form of 'Levodopa' [1] through-out the day. The amount required varies by individual and also by what is happening on that day, e.g. stressful situations, variations in food, and variations in excretion. Further, excess Dopamine will also cause unwanted side effects and tremor will return once the dose wears off. Traditionally, we may wish to directly address the impairment – in this case the tremor – by creating novel technical solutions for specific aspects of life. In some cases this is exactly the correct path to take; however, we might also want to address medication management by developing – for instance – better algorithms that monitor behaviour to enable adaptive medication doses; and therefore, reducing tremor across the board and thereby addressing the impairment indirectly.

With this mindset, we assert that the solution space is bounded by the following types while also acknowledging that here is certain overlaps into traditional accessibility and therefore the opportunity to leverage solutions across the domain.

2.1 Combinatorial Impairments

Every person has a range of motor, cognitive, and sensory abilities. Individual abilities are simply points on a continuum of multiple dimensions of human abilities. Those categorised as impaired have some abilities that differ from the 'average', often by an arbitrary amount. Such difference is evident with 'ageing', which inevitably and naturally results in a gradual decline of sensory (e.g. visual perception), cognitive (e.g. memory, recall, and processing), and motor (e.g. tactile spatial acuity, strength) abilities [18, 21, 22]. Each of the human abilities declines at different rates to one another for each individual, resulting in varying levels of impairments. In the specific case of older adults, they are more prone to other health conditions such as Dementia, Stroke, and Parkinson's Disease.

These multiple declines can interact and create combinatorial impairments that are greater than the effects of the individual impairments. For example, low-intensity impairments in visual perception and lack of experience with technology can result in significant accessibility barriers. Reduced tactile sensitivity and visual acuity that arise from Diabetes is another example of combinatorial impairments that may prevent people from effectively using technology. Still, dealing with these low-intensity impairments can be challenging. Even if current systems provide accessibility features, they are usually grouped under the banner of 'disability', which might not match users' views of themselves.

Combinatorial impairments can also result from the interaction between health and situational conditions [20, 26]. Naftali and Findlater [26] identified multiple instances where motor-impaired users experienced SIID, such as the ability to retrieve their phone or answer calls while in transit. Previous research has also attempted to draw similarities between older adults with increase physiological tremor and young adults walking, resulting in the concept of 'disability continuum' where both situationally- and health-impaired users' performance was interleaved [17]. Moreover, similar coping solutions could be applied.

Although the low intensity and mild impairments can make it harder to use technology, combinatorial impairments resulting

from severe individual impairments (e.g. visual, motor, and voice) can render current technologies completely useless [27]. Although assistive technologies can cope with each individual impairment, the lack of interoperability pertaining to all aspects of interfacing, make them utterly ineffective. Nevertheless, most research into accessibility continues to focus on a single disability. Accessibility solutions rarely consider the multi-dimensional nature of human abilities, and more importantly, their combinatorial effect.

Case study 1: Developing an app for people with chronic obstructive pulmonary disease (COPD)

In a previous project, an app was developed for people with COPD that provided education about COPD and used experience sampling to assess symptoms and medication intake. It initially involved extensive patient involvement work, such as attending COPD support group meetings and respiratory events, to establish patients' views on using a smartphone app for COPD self-management. Many had limited, or no experience using smartphones or technology in general but were generally receptive to the idea.

Together with people with COPD, paper prototypes (or wireframes) were developed which we used as templates to design an initial prototype app. The prototype app was then tested together with people with COPD (N=5) in a usability study using the Think Aloud paradigm (i.e. participants used the app while concurrently vocalising their thoughts). The study highlighted several key accessibility issues that arose as a result of combinatorial impairments related to COPD. The following impairments became apparent in our usability study:

- **Manual dexterity:** Several users showed signs of reduced manual dexterity, meaning that they struggled to operate features such as sliders and small toggle switches;
- **Visual impairments:** Many users had visual impairments to varying degrees, making it difficult to read smaller fonts and engage with smaller fields on the display (e.g. default virtual keyboard within smartphones);
- **Low familiarity with technology:** All users had either no or limited familiarity with smartphone usage, which meant common operations such as tapping fields on the screen were challenging; for example, participants attempted to use their fingernails or pressed their fingers down on the screen instead of lightly tapping;
- **Low (health) literacy:** The app aimed to collect data from patients about symptoms and medication intake and feed this back to users to help them understand their health status. Users did not tend to have the educational foundations required to interpret complex data visualisations and preferred simple, straightforward visualisations and either lay

language or terminology commonly used by health-care professionals (e.g. mucus).

It is important to note that these impairments tended to interact and exacerbate each other. For example, participants struggled with toggle switches not only because their visual and manual dexterity impairments made them challenging to operate, but also because they were less familiar with smartphone usage and therefore struggled to interpret their meaning. As a result, users often switched features such as reminders on or off without intending to, entered incorrect symptom information, and struggled to enter correct usernames and passwords to access the app. The latter is particularly important because health apps that collect personal data require secure password protection, but this can be challenging to realise when users face multiple impairments.

COPD is most common in older adults, meaning that people living with this condition are often vulnerable to other conditions that contribute to functional disability, such as osteoporosis [14]. Moreover, health outcomes are often worse in those who are socioeconomically deprived and have low education levels [11]. As such, those with the worst health outcomes who need support the most tend to have higher numbers of barriers to accessing technology that could help them manage their conditions.

2.2 Dynamic Impairment

Some examples of dynamic impairment that can vary in both magnitude and extent [22] can be seen in cardiovascular conditions, where oxygen demand does not meet available supply. Two such conditions are Angina pectoris and Intermittent Claudication (IC). The latter presents as leg pain caused by exertion, which passes with rest [3]. The pain usually affects the calf and sometimes the thigh/buttock [7]. The condition is caused by peripheral arterial disease, which results in these individuals having under 50% of the walking ability of their age-matched control group [3]. This condition has been shown to impact on walking distance/ability, emotional state, mental health, and social function [16]. IC is said to exist in around a fifth of people aged over 65 years [7].

Pain is caused by obstructed arterial blood flow to muscle tissue causing subsequent ischemia [7]. One of the most effective treatments for IC is walking exercise programmes, including both home-based and supervised programs. Benefits are seen when individuals can walk beyond the point of experiencing pain, which can be a barrier for patients [3]. Evidence has, however, demonstrated that there are opportunities to improve engagement in such treatments through self-management interventions that incorporate behaviour-change approaches [3].

Atherosclerosis is the mechanism leading to IC and refers to a process where arteries become hardened by the formation of plaques (composed of cholesterol and triglycerides) [8]. Atherosclerosis is also the underlying pathology involved in angina. Angina derives from the Latin word meaning pain and is often used to describe chest pain (angina pectoris). The condition can be stable

where the pain is triggered by exertion, or unstable when symptoms can occur at rest [8].

In many ways, the dynamic component of these HIIDs can be the most challenging to deal with. As with many chronic conditions, one can adapt somewhat to the loss or decline of function over time, especially if this happens over a prolonged period and in a gradual way. In contrast, the rapid shifting of state involved in dynamic impairments makes achieving homeostasis difficult due to the rapid changes and lack of time to adapt to these changing states. In turn, it makes developing interventions or providing accessibility solutions for such health conditions challenging. Detecting these rapidly changing barriers relies on the creation of effective computing algorithms, which also need to be framed by sound and evaluated psychological models. To achieve these goals we need to consider the application of a 'team science' approach, combining the expertise of health care professionals, psychologists, computer scientists and patients themselves.

Case study 2: Dynamic musculoskeletal issues for people with Facioscapulohumeral muscular dystrophy (FSHD)

FSHD is a degenerative genetic disorder characterised by progressive muscle loss and weakness which predominantly affects the face, shoulders and upper arms. Mobility can also be affected with around 20% of people affected becoming a wheelchair user [5, 28].

The condition is an autosomal dominant inherited disorder caused by activation of a gene (DUX4) that produces a protein that in turn damages muscle cells, which leads to wasting of muscle tissue and inflammation [12, 23]. Similarly to many degenerative conditions, increasing disability and loss of function occurs over a period of time (sometimes over decades). In addition to this overall loss of function, there are daily dynamic impairments that occur with the condition, such as levels of pain and fatigue.

Aside from some of the more serious visual problems associated with the condition, such as retinal telangiectasias and Coat's disease, many FSHD patients also suffer from muscle weakness around the eyes in the orbicularis muscles [23]. This can lead to the eyes not being able to fully close, affecting blinking and in some cases leading to corneal abrasions from eyes not closing completely when sleeping. Eye muscle weakness can, in turn, lead to other issues, such as frequent conjunctivitis and ulceration of the cornea [23].

An FSHD patient's ability to look at display screens becomes increasingly difficult as the working day progresses due to fatigue of the eye muscles, making computer-based tasks increasingly difficult over time with blurred vision and sore eyes. Moreover, muscle pain and weakness in the arms makes using a keyboard and mouse progressively challenging. One might think of using technology such as voice recognition (text to speech) as assistive technology in this regard. Pragmatic issues, such as office sharing can make such options impractical. Nevertheless, muscles

around the mouth also become fatigued and painful with talking for sustained periods.

The best way of dealing with these daily dynamic effects would be to alternate between approaches allowing for some recovery. For these approaches to be truly effective, both the technology and workplace would need to be more adaptive than they currently are.

2.3 Comorbidities

Health-induced impairments are defined to a great extent by the underlying condition. The impairment is, therefore, a co-morbidity, and this can mean that effective accessibility solutions may be better addressed if they are directed towards the underlying condition. Co-morbidity impairments vary across the health domain. However, we can see there are numerous commonalities that occur in general. Indeed, there are many first-hand accounts related to health conditions ranging from ALS (or Motor Neurone Disease – MND) to valvular Heart Disease³. However, understanding the needs of a specific user group can be challenging. This is especially the case if the user group exhibits certain characteristics that make the data sensitive, if the data is complex, if the interpretation of the data requires a domain expert, or if the ethical approval for that data (as is often the case in the health domain) requires it to remain confidential. Indeed, anonymised data is often the only way to access formal data, and so informal data sources are often preferable because they are primarily transparent and in-depth, but objectivity may be sacrificed in favour of anecdotal experiences. This said, by analysing these first-hand accounts, it is often possible to decide what affects a person's quality of life. These are not only limited to the condition but the everyday effect of it. The effects are often impairments and are often under-investigated.

For instance, a high number of health conditions affect mobility, which can be directly based on aspects related to the muscles as we have already alluded to via tremor in Parkinson's Disease. However, limited mobility is also related to respiratory/cardio conditions – an association with heart conditions such as Angina and respiratory conditions such as Asthma; likewise Chronic Obstructive Pulmonary Disease (COPD). These kinds of conditions directly affect mobility; however, direct accessibility solutions aimed at addressing these impairments are unlikely to be effective. For instance, people with lung cancer can suffer debilitating symptoms, and also severe side- and after-effects of surgery, chemotherapy and radiotherapy. These include breathing problems, pain, severe weight loss, nausea and fatigue. People experiencing such symptoms often find it difficult to leave the house. Indeed, breathlessness – which can be very tiring and distressing – is a common problem for those with lung cancer and may be due to the position of the tumour as well as to physical, psychological, and emotional factors, but may also be due to the treatments themselves, such as pneumonectomy, when an entire lung is removed.

We can see that mobility impairment due to increased breathlessness, which stems from either a health condition, treatment for

that condition, or medication associated with the condition might have a number of different accessibility possibilities. The mobility impairment can be directly addressed, but this impairment is likely to be dynamic in scope and intensity. Thus, it may be more effective to look for solutions to breathlessness or to assist in monitoring technology to better predict medication requirements which in turn may reduce breathlessness.

2.4 Socio-Technical Impairments

At present, the Socio-Technical barriers arising from HIIDs are not well understood. The third-party analysis allowed us to identify ten different types of barriers mapping. These barriers seem quite straight forward but are actually quite pernicious:

- (1) Low income: Many people with chronic conditions are unable to work. Some receive state benefits, but many are unable to access even this income. A lack of money often impacts on the person's ability in the way that they use technology.
- (2) Low literacy levels: Many patients feel overwhelmed by large amounts of information. They often do not read the leaflets that they are given by Health Care Professionals (HCP)s.
- (3) Dislike of reading: Many patients do not enjoy reading. They often do not read the leaflets that they are given by HCPs.
- (4) Lack of understanding of how to reduce symptoms and improve general health, e.g. through exercise: Many patients would like to self-treat certain symptoms, and improve their general health through exercise, for example, but do not know how to go about this.
- (5) Reluctance to ask for support: It is common for patients not to want to 'bother' others with queries, even relating to quite serious symptoms. They often wait until their next scheduled appointment, which may be too late to treat them.
- (6) Fear of using technology to search for information: Many patients are fearful of using the Web to search for information about their condition. They feel overwhelmed by the amount of information and concerned that it is not accurate. They are often anxious about the cancer returning and what the future holds in general, and do not wish to see information that is not directly relevant to their current situation. They are also very sensitive to the way in which information is presented, and want information that is supportive and helpful, not merely (and sometimes brutally) factual.
- (7) Inadequate healthcare resources: Although some patients would like to spend more time with HCPs (and HCPs would like to spend more time with patients), there are simply too few of them to make this possible.
- (8) Lack of communication between HCPs: Many different HCPs are involved in treating and following-up patients. At present, there is no cohesive follow-up plan seen by everyone, so time is wasted collecting information several times, and there is a danger that some simply 'falls through the net'.
- (9) Lack of familiarity and/or experience with technology: Patients are typically older people who have worked in manual jobs and have had little experience using computers, smartphones or similar technology.

³via website such as Health talk <http://www.healthtalk.org> or Macmillan Cancer Stories <https://www.macmillan.org.uk/information-and-support/resources-and-publications/stories>.

- (10) Lack of familiarity and/or experience of the Web: This is a specific case of the point above. As many patients do not own computers, they have little experience in the use of the Web, what services are available, and how those services might be accessed - or advice given - electronically.

We can see that the context of an intervention is important and complex, impacting on feasibility, acceptability, and ultimately effectiveness. There are many factors that need consideration. Some are tangential to the health condition but are an indicator of it. We know, for instance, that lung cancer is associated with low income, that conditions associated with ageing impact technology adoption and continuance, and that conditions related to cognition may foster a dislike of reading.

Case study 3: Web use for symptom appraisal among people with lung cancer

Lung cancer is one of the most common cancer types, and it is the leading cause of cancer deaths worldwide [13]. Lung cancer rates are highest among older adults (average age of onset is 70 years) and those of low socioeconomic status [33].

In previous research, a survey was conducted among 113 recently diagnosed lung cancer patients [25]. This research aimed to explore whether people with lung cancer access the Web to help them understand their symptoms before diagnosis and whether this influences their decision to seek medical help. The study showed that only a small proportion (20%) had used the Web to appraise their symptoms. In the cases where the Web was used, 87% of searches were conducted either by or with the help of a family member or friend.

This result suggests that there are barriers to using the Web for health information among people with lung cancer. We explored this further by conducting interviews with a sub-sample of 33 patients and/or their next-of-kin and found important socio-technical barriers to Web use for symptom appraisal, including:

- **Lack of familiarity with technology:** Several participants expressed interest in accessing the Web but lacked the knowledge and skills to accomplish it
- **Fear of using technology:** Participants expressed a worry that they might "make a mess of everything" if they attempted to use technology
- **Fear of using technology to search for information:** Participants were reportedly worried that searching for health information online may overwhelm or frighten them. This was particularly interesting because younger participants who were more familiar with technology reported using search strategies acquired as a result of familiarity with online information searches that helped them mitigate such concerns. Thus, participants' lack of familiarity and/or experience of the Web exacerbated

their fear of using the Web as a health information resource.

Our overall results indicated that, when lung cancer patients or their next-of-kin used the Web to search for symptoms, this reportedly influenced their decisions around seeking medical advice. Importantly, participants reported accessing Web-based information when they felt dismissed or inadequately informed by their healthcare professionals [25]. The information found online helped them decide whether to seek further help, e.g. by requesting more diagnostic tests. As such, it is concerning to consider that those who may need health information to inform important decisions - such as when and how to seek medical help - may have limited access to the Web due to socio-technical barriers.

3 PROVIDING ACCESSIBILITY SOLUTIONS FOR HIIDS

Understanding the term 'disability' is fundamental to understanding accessibility - the two terms being inextricably linked. In this case, accessibility is an attempt to remove barriers to interaction between features in society and the environment and therefore enable interaction by accommodating features of a person's body. This said, it is fair to characterise that the field's implicit focus of attention is on permanent disabilities; with the exclusion of SIIDs.

Accessibility solutions vary widely. HIIDs affect parts of a person's life cutting across the virtual and real [4]. To limit solutions to a single domain (as in the Web) alone will probably not help us remove barriers and increase people's quality of life. And quality of life is what we are talking about... alleviating some of the symptoms of a health condition such that the associated disability is transitively addressed. But it is likely that we will need think across arbitrary domain boundaries to affect change in the accessibility application area. We might foresee that combinatorial work addressing people, their environment, and society will be needed to maximise the impact of the accessibility work we undertake.

Our work is unlikely to cure a health condition; this is not our argument and is probably beyond the scope of the domain. Indeed, if a cure for, say PD, arose then the associated HIIDs would be addressed across the board; more likely we will have some success in address the symptoms of a health condition (as opposed to the underlying condition directly) which will impact its expression as an accessibility barrier.

To see how closely our concept of HIIDs is currently understood and addressed we compared the health-induced impairments identified in our case studies against the Web Content Accessibility Guidelines (WCAG) 2.0 and W4A [15]. This analysis revealed that the existing standards broadly speaking address the accessibility needs of those with health-induced impairments including challenges related to visual impairments, reduced manual dexterity, and sociotechnical challenges like lack of familiarity with or fear of technology. However, they are often not implemented in ways that are maximally beneficial to users with health-induced impairments. For example, a success criterion within WCAG 2.0 purports that

text should be resizable without assistive technology up to 200 percent. Many websites and in particular many smartphone/tablet applications do not allow text resizing.

WCAG also recommends providing descriptive labels for controls that require user input. Case study 1 highlights that this needs to be incorporated to a higher degree than usual to address the needs of users with sociotechnical challenges compounded by visual/manual dexterity issues. Widgets and controls that are frequently used in Web and smartphone/tablet applications such as clock widgets and slider controls often do not include such labelling, instead, rely on users' familiarity with common icons and symbols used in digital communications. We, therefore, suggest that more (and larger) text buttons and icons with text need to be used for certain user groups.

There are different techniques that can be used to meet the success criteria outlined in WCAG; at times, the use of certain techniques may not be beneficial to certain users, and using some techniques over others may maximise accessibility for particular user groups. Future work should focus on identifying which techniques are maximally beneficial to users with different HIIDs. Furthermore, user studies can be conducted to better understand the scope and coverage of WCAG with respect to the needs of people with different HIIDs.

4 THE FUTURE

In the future, we might see how we can leverage solutions and work from disjoint domains to help us in addressing HIIDs. Rosalind Picard, for instance, wrote a position paper in the late 1990s about the potential of 'Affective Computing' [29]. This paper talks about the ability of machines to recognise and respond to human emotion. The challenges involved in this task are considerable, many of which are acknowledged by Picard herself in a follow-up paper [30]. However, the potential of Affective computing is becoming increasingly plausible with the ubiquity of machine learning methods and techniques, along with the improvement in the quality of sensing devices with reduced manufacturing costs. Consider, for example, the ability of emotional recognition through facial expression with machine learning methods. A recent example of this can be seen for automating coding for emotional dysregulation research. This method applied computer vision and machine learning to automate the coding of facial expression that converges with a validated human coding scheme [2]; a very powerful example of the kind of real world cross-disciplinary we have been espousing. Further consider that certain individuals may not be able to easily express facial emotion, for example, someone who has suffered a stroke, or has a muscular weakness (even if demonstrating temporal variation). Such individuals may very well benefit from the confluence of domains and work so as to be able to express and recognise emotion more easily. However, they may not be able to easily access this novel technology, making an affective computing disparity similar to that of the 'digital divide', where access to the Internet and computing is not equally available to all.

We see our understanding of the accessibility domain expanding in the future to encompass impairments that may be transitory or those that are co-related (a co-morbidity) to a condition unrelated to the impairment, and such that treatment of that underlying condition may remove the related impairment. For instance, a person

with Lung Cancer may be less able to move, may become breathless and fatigued quicker, may have mobility impairments. However, these impairments are normally resolved once the underlying condition is addressed or treated.

Previous research had an implicit focus on permanent disabilities and have been less focused on these seemingly transient impairments. We predict that in the future we will become more inclusive, and begin to address these "Health-induced impairments and disabilities (HIID)" [24, 25].

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