Faculty of Science and Engineering
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Integrated Web Accessibility Guidelines for Users on the Autism Spectrum – from Specification to Implementation

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Declaration

To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Human Ethics

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number HRE2017-0621.

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Abstract

There can be multiple barriers for people on the autism spectrum when it comes to accessing information on the web. For instance, they may struggle navigating websites because their cognitive profile often exhibits deficiencies in attention, memory, perception and problem solving, and this affects the manner in which they interact with computers. To date, web accessibility research has focussed predominantly on hearing and vision-impaired users. Despite the fact that many web accessibility standards and guidelines have been studied and published, it remains unclear exactly what web design guidelines should be followed to create accessible web interfaces for neuro-diverse users, especially those on the autism spectrum. Further research into web accessibility for autistic users was needed to advance knowledge and understanding of web interaction for these individuals and to improve the entire community's web experience. Therefore, the overall aim of this thesis was to explore web accessibility for users on the autism spectrum, from specification to implementation.

A scoping review, a focus group, and an affinity diagram technique were implemented to gather the requirements that would allow the web design necessities and guidelines for creating accessible desktop websites for autistic users to be identified. As a result of this integrated approach, a compendium of 13 web design guidelines was obtained and presented as a web design framework for autistic users. This web design framework was the input to continue the software development process of design, implementation and evaluation.

The software design involved the reuse and expansion of ontologies in the domain of autism and web user interfaces and resulted in the creation of the webDesignASD ontology. A transport-planning website, namely Adaptable Maps, which included the web design guidelines and the webDesignASD ontology, was used as a case study to compare its usability versus current web mapping websites (Google maps, Apple maps, Bing maps, and Waze). An integrated approach was used to evaluate the proposed framework, whereby a survey and an eye-tracking technique were implemented with 25 adults on the autism spectrum.

This research found that regardless of the myriad sources of web accessibility standards and web interface design guidelines available to web developers and web content creators, there was no centralised or evident-based information about web accessibility for users on the autism spectrum. A compendium of 13 web interface design guidelines was presented based on online information and the own experience of autistic users. Further findings came to light after the participants performed some tasks of scanning and route-finding on the different websites at the same time having their visual behaviour recorded by a remote eye-tracker. The implementation and evaluation of the transport-planning website concluded that the most popular and known website among participants was not always the most accessible when it was evaluated against fixations counts and the total time that the participants took to accomplish different tasks. Longer fixations on areas of interest of all websites highlighted the importance of having simple navigation and meaningful headings, icons, labels and text to facilitate understanding and readability for people on the autism spectrum.

Additionally, it was found that the interface elements preferred by autistic users of a webpage were: a white background colour, medium font size (12 points), black Arial font and, normal spacing between paragraphs, with the buttons colour-filled to be clearly identified among surrounding elements on the webpage. The most displeasing problems of the current transport-planning websites were found to be related to colour-contrast, lack or misinterpretation of icons, loading-page lags, difficulties with the layout and navigation, and the presentation of many simultaneous options on a single page.

For web developers and web content creators, these findings offer clear and usable guidelines for the design of web user interfaces and can provide them with a solid baseline to continue improving the web experience of autistic users, and therefore of the whole community.

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List of most relevant abbreviations

APA	American Psychiatric Association
ASD	Autism Spectrum Disorder
COGA TF	Cognitive and Learning Disabilities Accessibility Task Force
CSS	Cascading Style Sheets
HTML	Hypertext Markup Language
ICF	International Classification of Functioning, Disability and Health
ISO	International Organization for Standardization
SWRL	Semantic Web Rule Language
W3C	World Wide Web Consortium
WAI	Web Accessibility Initiative
WCAG	Web Content Accessibility Guidelines
WHO	World Health Organization
WWW **The Web** **The Internet**	World Wide Web

Autism terminology and approach

There has been much discussion in recent years regarding the terminology to be used when referring to people having been diagnosed with Autism Spectrum Disorder – ASD (Draper, 2018; Kapp, Gillespie-Lynch, Sherman, & Hutman, 2013; Kenny et al., 2016). The term ASD is commonly used when referring to the medical diagnosis, and it is generally the terminology used by health professionals and researchers, i.e., a person with ASD, individuals with ASD. Likewise, the Australian Network on Disability (Australian Network on Disability, 2019) recommends the use of people-first language i.e., people, person, or individual with ASD.

On the other hand, there is a growing movement advocating for the use of autistic person or individual (Draper, 2018). They claim that autism is within the individual, and given that it is a lifelong condition, the individual diagnosed should not be labelled as someone "with" the condition; it is not possible to be a person with ASD for one day and another day without it.

The approach of this thesis is to focus on the abilities and strengths of the individual. The medical model classifies the autism condition as a disorder, a problem of the individual and a direct consequence of a health condition, and the social model considers disability to be a socially created problem which can be resolved by the full integration of the individual into society (Bölte et al., 2014). On their own, neither model is adequate, although both are partially valid. A better approach is the bio-psycho-social model (World Health Organization, 2002) which is based on a coherent view of different perspectives of health: biological, individual and social. Therefore, this thesis follows the bio-psycho-social model and aims towards adapting the environment rather than changing the individual to improve their level of functioning.

Consequently, disability and disorder terminologies will not be prevalent, and, as long as citations and referencing allow, the individuals diagnosed with autism spectrum disorder will be referred to as autistic individuals in accordance with the preferences of the autistic community (Moran, 2016).

Statement of contributors

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Statement of Contributions

The following peer-reviewed conference proceedings were declared into the thesis.

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I acknowledge that these represent my contribution to the above research output

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Conference posters

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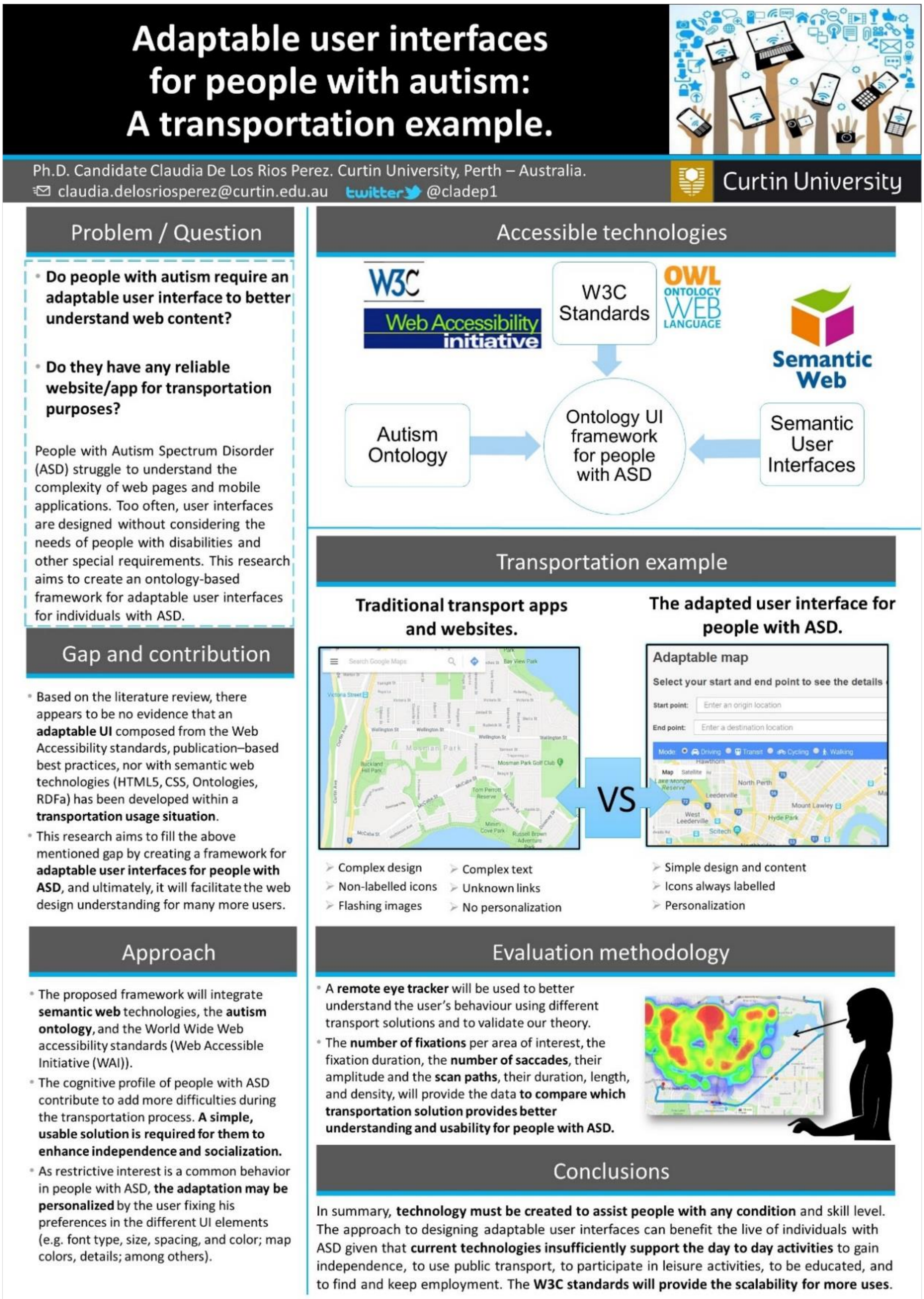

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when I was happy and motivated you were more excited than me.

Because when I did not believe I could do it you pushed me to my limits.

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I love you with all my life. I dedicate this thesis to you, my forever loved husband, Jorge Mario Correa Henao.

Chapter 1 Introduction

A diagnosis of Autism spectrum disorder requires observable impairments in the areas of social functioning and communication and the presence of repetitive and restricted activities (American Psychiatric Association, 2013). Autistic people often present a developmental profile characterised by difficulties in social, academic, and/or occupational functioning (American Psychiatric Association, 2014). In some cases their attention, memory, perception and problem-solving affect the manner in which they interact with computers, leading to lower performance than their non-autistic peers (Friedman & Nelson Bryen, 2007).

Nevertheless, computer-based technology has shown significant benefits for supporting autistic individuals if it is used and developed with appropriate standards and practices (Ploog, Scharf, Nelson, & Brooks, 2013). Most autistic individuals can benefit immensely from using the Web, for example, educational software can provide training on social interactions and emotions, skills that later can be practised in real-life settings (Ploog et al., 2013). As professional support can be expensive, providing in-home educational software can also reduce the cost of treatments and interventions (Goodwin, 2008). Moreover, autistic individuals have a tendency to be socially isolated and having access to the Web can provide social connection and facilitate social participation without the increased anxiety that often accompanies face-to-face interactions (Jordan, 2010).

To accommodate autistic users, content and design on the Web should reflect their preferences such as short and precise instructions, contrasting visual elements and routine interaction design, among other characteristics (Kimball & Smith, 2007). These accessibility features are not always present in websites or mobile applications, showing lack of strategic web design, lack of awareness of autistic user needs, and unfamiliarity with the autistic cognitive profile when dealing with web navigation (Darejeh & Singh, 2013; Pavlov, 2014).

There have been several published web interface guidelines aiming to improve the user experience and usability on the Web for autistic users and individuals with related conditions (Britto & Pizzolato, 2016; Davis, Dautenhahn, Powell, & Nehaniv, 2010; Freyhoff, 1998; Friedman & Nelson Bryen, 2007; Garrett, 2002; Poulson & Nicolle, 2004). However, to date, there have been no attempts at presenting the user experience and the web usability as a unified design framework to guide web designers and community members when planning and developing websites that are usable and accessible for autistic users. The user experience refers to the users' perception and response from the use of a website (International Organization for Standardization ISO, 2018), and the web usability is a quality attribute relating to how easy is it to use a website, how quickly people learn to use it, how efficient the users are using it, how memorable it is, how error-prone it is, and how much users like using it (Nielsen & Loranger, 2006).

As a consequence of this issue, this thesis explores whether autistic users have a good user experience navigating desktop websites when the design and implementation of the website follow web design guidelines and adaptability features based on the abilities and needs of autistic individuals. This research attempts to extend the knowledge of web navigation for autistic users by providing a web interface design framework, including web guidelines, tools and best practice for planning and designing websites aimed at a good user experience for autistic users. The aforementioned framework was designed and implemented using semantic web technologies and it was evaluated in a use case of a transport-planning website.

1.1 Statement of the problem

When compared with human-human communication, human-computer interaction is clearly more primitive given that it is eminently more difficult to make the computer comprehend human gestures, intuitions, or personalities (Rothrock, Koubek, Fuchs, Haas, & Salvendy, 2002). Therefore, the process to understand and navigate desktop websites can be complex and requires some levels of cognitive processing according to the difficulty in which the information and the design are presented in the user interface or screen (Seok, 2008; W3C, 2019b). People with neurodevelopmental conditions such as autism may struggle navigating websites because often their cognitive profile reveals deficiencies in attention, memory, perception and problem-solving, which affect the manner in which they interact with computers (Friedman & Nelson Bryen, 2007).

Moreover, as cognitive and physical impairments exist on a wide spectrum amongst people with the same autism diagnosis (Benton, Johnson, Brosnan, Ashwin, & Grawemeyer, 2011; Bölte et al., 2014; Brown & Elder, 2014; Frith & Happé, 1994; Mejía-Figueroa & Juárez-Ramírez, 2013), there is great heterogeneity of web requirements that make it difficult to design web user interfaces that take into account the different needs for all type of users into a single solution (Abascal & Nicolle, 2005; Al-Badi, Ali, & Al-Balushi, 2012; Fischer, 2001; Friedman & Nelson Bryen, 2007; Grabinger, Aplin, & Ponnappa - Brenner, 2008; Mejía-Figueroa & Juárez-Ramírez, 2015). A simple query on search-engines and scientific databases about web interface accessibility brings up a myriad of titles that address the topic. Despite this, there is lack of available open-access research on web accessibility needs for individuals with neurodevelopmental conditions (W3C, 2019d), and people designing and creating accessible web interfaces are often unable to find out what techniques are proven to address the needs of autistic users (Abascal & Nicolle, 2005; Eraslan, Yaneva, Yesilada, & Harper, 2017; W3C, 2019a).

Nevertheless, as previously mentioned, there are web standards and web interface guidelines that are referred to by web developers and web content creators to assist in the design and implementation of websites that are accessible to the majority of users (Al-Badi et al., 2012; Garrett, 2002; W3C, 2016). Web accessibility for autistic people has been studied using different approaches (Britto & Pizzolato, 2016; Dattolo & Luccio, 2017; Davis et al., 2010; Mejía-Figueroa & Juárez-Ramírez, 2013; Pavlov, 2014) but, to date, open-access and centralised information is scarce (Eraslan et al., 2017; W3C, 2019a). It remains unclear which user interface elements autistic users perceive as less accessible, and which features of a website are the ones that create barriers for good user experience (Eraslan, Yaneva, Yesilada, & Harper, 2018). Consequently, there is a need to centralise the information required to develop accessible websites for autistic people, and this information must take into account the international web standards, relevant publications, and the point of view of autistic people and the community involved with autism.

1.2 Significance

1.2.1 The right of Internet access and web navigation

The United Nations (UN) in its Universal Declaration of Human Rights (UDHR), Article 19, promotes that every individual has the Universal Right to freedom of opinion and expression; this right includes freedom to hold opinions without interference and to seek, receive and impart information and ideas through any media and regardless of frontiers (United Nations, 2019). It may, therefore, be suggested that in order to be able to execute this freedom, is of critical importance for an individual, and for society, to have full access to the Web. Internet access has two main components: content and infrastructure, and any limitation or control at the content level should be understood as censorship of freedom of speech (Kurbalija, 2016).

The UN is condemning countries that intentionally disrupt citizens' Internet access given that on previous statements on digital rights, they have reaffirmed that "the same rights people have offline must also be protected online" (United Nations, 2019). However, UDHR Article 29 about the protection of public order and general welfare endorses some control at government level; there is, in fact, a debate between Article 19, freedom of opinion and expression, and Article 29, how to keep public order during protests and encounters between citizens and governments (Joyce, 2015).

The right to Internet access itself has not been declared yet in the UDHR because formulating such a statement is complicated, requiring the consensus of many international actors (Hick, Halpin, & Hoskins, 2016; Joyce, 2015). There are several variables to be analysed and weighed in order to reach a consensus: freedom of expression and safety, privacy concerns, data portability, fact-checking, elections interference, illegal content, etc. Nevertheless the UN is constantly working together with different governments towards ensuring the right to have an open and accessible Web (Hick et al., 2016; Joyce, 2015; Mumford, 2018).

It is expected that in 2019 half of the world's population will be connected to the Internet; the United Nations' Broadband Commission for Sustainable Development has set 2025 as the target when the total world population will be provided Internet access (Mumford, 2018). This challenge requires dealing not only with the technical challenges of connecting 7.6 billion people but also with legal, sociocultural, economic and security factors (Kurbalija, 2016; Mumford, 2018). Despite these challenges, the Internet is becoming the main source for people to stay informed and current on news, health information, and to communicate with family, friends and third party entities (W3C, 2015). It also provides independence and facilitates education and employment (W3C, 2019a). People who cannot use the Internet will have an increased feeling of disadvantage in regard to information access and of being alienated from society, potentially suffering the effects of digital social exclusion and the so-called "digital divide" (Norris, 2001; W3C, 2015; Warschauer, 2004).

Web accessibility is a fundamental aspect of having the Web available for all. Physical environments are regulated to be accessible for people with all conditions but cyberspace remains unregulated in this regard (Loiacono & Djamasbi, 2013). Sir Tim Berners-Lee, creator of the first successful communication between a Hypertext Transfer Protocol (HTTP) client and server via the Internet or what we know as the Web (Berners-Lee, 1999), explained his view on why the Web should be available and usable for all (W3C, 2016):

> *The goal of the Web is to serve humanity. We build it now so that those who come to it later will be able to create things that we cannot ourselves imagine.*

Nevertheless, for the Web to be available and accessible for all, there are some challenges that a user needs to overcome in accessing the Web, such as:

- Internet connectivity – being able to connect to the Web.
- Access to hardware/devices for accessing the Web – Computers, laptops, tablets, smartphones.
- Political factors – people can have Internet connectivity and the hardware to access the Web but some countries have policies that do not allow people to have free Web access and often limit and control the content (Kurbalija, 2016).
- Accessibility – web accessibility refers to the capability of all people to access the Web regardless of any disability type or severity of impairment. It is the inclusive practice of ensuring there are no barriers that prevent interaction with, or access to, websites on the World Wide Web (W3C, 2016).

As expressed by the W3C consortium (W3C, 2016):

> *The Web is fundamentally designed to work for all people, whatever their hardware, software, language, culture, location, or physical or mental ability. When the Web meets this goal, it is accessible to people with a diverse range of hearing, movement, sight and cognitive ability.*

Web accessibility can, therefore, be regarded as a pivotal need for all people. People with a disability have same rights to access the Web as people with no disability (Australian Human Rights Commission, 2014; Hick et al., 2016; Joyce, 2015). Federal agencies and colleges that are mandated to have accessible websites, do indeed have higher levels of accessible websites than corporate sites do, and it is of high concern that as close to 95% of Fortune 100 corporate websites remain inaccessible (Loiacono & Djamasbi, 2013).

1.2.2 Solve for one, extend to many

For many years, limited attention has been given to the web accessibility needs of individuals with neurodevelopmental conditions. Referred to as "neuro-diverse users" (Kapp et al., 2013; W3C, 2019a), this community include individuals with diagnosis of Autism Spectrum disorder (ASD), dyspraxia, dyscalculia, dyslexia, Attention deficit hyperactivity disorder (ADHD) and Tourette syndrome, among other related neurodevelopmental conditions (Kapp et al., 2013; W3C, 2015). Creating web accessibility standards for these communities require a high level of analysis as their cognitive processing when interacting with web interfaces differs from that of neuro-typical users (Eraslan et al., 2018).

The work of the Cognitive and Learning Disabilities Accessibility Task Force's (COGA TF), as part of the Cognitive Accessibility User Research by the World Wide Web Consortium (W3C), is the first attempt to create a web standard for neuro-diverse users (W3C, 2015). One of the significant findings of this task force is that if a web interface is usable and accessible for autistic users, it is highly likely to be usable for the majority of neuro-diverse users, given that they share similar challenges when using the Web (W3C, 2015).

Microsoft's inclusive design principle "Solve for one, extend to many" (Microsoft, 2019) shows that solving accessibility issues for one community, positively impacts the rest of the other users (Microsoft, 2019). Solutions aiming for improving the user experience for autistic users, improve the user experience (Britto & Pizzolato, 2016; Dattolo & Luccio, 2017) and web performance (Schmutz, Sonderegger, & Sauer, 2016) of non-autistic users.

1.2.3 Centralised information about web accessibility for autistic users

Web user interface design guidelines aiming to improve the user experience of autistic users have been studied with different approaches, but to date, there is no centralised information that reports these findings. As part of the significant contributions, this thesis proposes a centralised web design framework containing complete documentation regarding how to create accessible websites for autistic users.

This research uses semantic web technology to centralise the information about the autism condition, the user preferences and the relationship between the domains of autism and web accessibility. The autism condition modelled in a machine language format (ontologies), gives the semantics to interconnect the human-knowledge about autism with technologies related to user interfaces and web design. It enables a powerful relationship where the web user interface can be adapted according to the user profile and preferences. Additionally, web interface adaptations for autistic users have been published (Britto & Pizzolato, 2016; Davis et al., 2010; Mejía-Figueroa & Juárez-Ramírez, 2013; Poulson & Nicolle, 2004) but none of them has taken into account the autism ontology (McCray, Trevvett, & Frost, 2014; Mugzach et al., 2015; Tu, Tennakoon, O'Connor, Shankar, & Das, 2008) to thoroughly analyse the autism profile when using web interfaces.

As sharing and reusing knowledge in a variety of systems is one of the main benefits of semantic technologies (Berners-Lee, 2006; Elias, Lohmann, & Auer, 2016), the proposed web design framework for autistic users is available for use by anyone interested in working with the generated documentation and exploring further implementations and improvements.

1.3 Aims and objectives

The overarching aim of this research is to present a comprehensive framework for web interface design for autistic users and to validate if autistic users have a good user experience navigating desktop websites when their design and implementation follow web design guidelines and adaptability features based on the presented framework.

Three specific research objectives will be addressed throughout the thesis as follows:

Objective One

The first objective was to define a web interface framework to develop desktop websites that aim to generate a good user experience for autistic users. The specific research question was: What are the required web interface design guidelines and adaptability features for creating a good user experience for an autistic user when they navigate desktop websites?

Objective Two

The second objective was to design the web interface framework for autistic users. The research question corresponding with this objective was: What is the design required to model the autism condition, the user interface elements, and the way these models interrelate in order for an autistic user to have a good user experience when they navigate desktop websites?

Objective Three

The third objective was to implement and evaluate a desktop website, based on the web interface framework, as a case study in the domain of transport planning. This implementation and evaluation validate the user experience of autistic users navigating different transport-planning websites. The research question that addressed this objective was: How is the current user experience of transport-planning websites by autistic users? This research presents the strengths and limitations of current transport-planning websites, and how a personalised transport-planning website performs against them for an autistic user.

1.4 Thesis structure

The research presented in this thesis encompassed five consecutive phases presented in seven chapters. Figure 1.1 provides an overview of the thesis structure and the chapters herein. The first and last phase are traditional phases that bookend the content of this thesis: Phase I: setting the scene, comprises Chapter 1 – Introduction, and Chapter 2 – Background. The last phase, Phase V, contains Chapter 6, as contributions and future work, and Chapter 7 as conclusions. The three internal phases follow the waterfall software development model (Sommerville, 2011) as Phase II: Requirements gathering, Phase III: Framework design, and Phase IV: Implementation and evaluation. Each phase produced a deliverable required by the next phase in the development of the thesis.

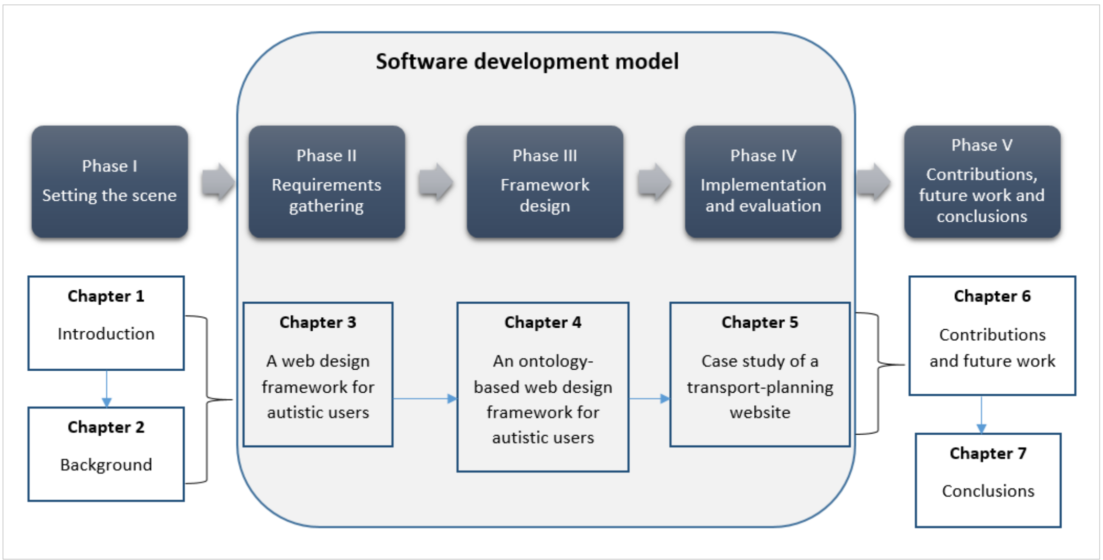


Figure 1.1 Overview of thesis structure

1.4.1 Phase I: Setting the scene

Setting the scene comprises Chapter 1 and Chapter 2 that together explain what the problem is, the gaps in the current literature that this thesis seeks to address, and the background information required to guide the reader into the domains covered in this research. Chapter 1 provides an introduction explaining the problem, current gap, significance of this research, the aim and scope of this thesis, the different research questions and objectives, and the general overview of the thesis structure.

Chapter 2 provides the background of the domains covered in this research, such as the autism condition and how autistic users use the Web, web accessibility and published works related to web interface design for autistic users, web semantic technologies and their use on web interface design.

1.4.2 Phase II: The requirements gathering

This phase encompasses Chapter 3 and aims to gather all requirements needed to define a web interface design framework to develop desktop websites accessible for autistic users. The framework includes web interface design guidelines, tools and best practices for planning and implementing desktop websites for autistic users.

This framework aims to facilitate the web design process for web developers, web content creators and anyone interested in generating a positive user experience for autistic users when using desktop websites.

1.4.3 Phase III: Framework design

This phase encompasses Chapter 4 and aims to outline the web interface design framework to be applied using the requirements gathered in the previous phase. The design is presented using semantic web technologies as a tool which enables knowledge of the autism condition and its implications on the different user interface elements required for a good web user experience for autistic users to be centralised, reused and shared. This chapter explains the technical solution, data and architecture to create the ontology-based web interface design framework.

This software-design used semantic web technologies such as Hypertext Markup Language (HTML), Cascading Style Sheets (CSS) and ontologies to create a generic website accessible for autistic users. The technology used in this implementation allows the adaptation of the user interface according to the user profile and user preferences.

1.4.4 Phase IV: Implementation and evaluation

This phase encompasses Chapter 5 where, in a case study of a transport-planning website, the requirements gathered in Phase II and the designed web framework of Phase III are implemented and evaluated.

The case study of a transport-planning website was carried out through a website called Adaptable-maps, and it was evaluated against current transport-planning websites in the same domain such as Google maps (https://www.google.com/maps), Microsoft Bing maps (https://www.bing.com/maps) and Waze (https://www.waze.com/en-GB/livemap).

1.4.5 Phase V: Contributions, future work and conclusions

To finalise, Phase V includes Chapter 6 and 7. Chapter 6 explains the different contributions of this research to the different areas of knowledge and lists some of the future work that should be explored. Chapter 7 presents the conclusions of this work, and is followed by the Bibliography.

1.5 Summary

This chapter has presented the introduction of the thesis, explained the problem statement, the significance of this research, listed the research aims and objectives, and finalised explaining the five different phases in which the thesis is developed. Chapter 2 is about the background of this research.

Chapter 2 Background

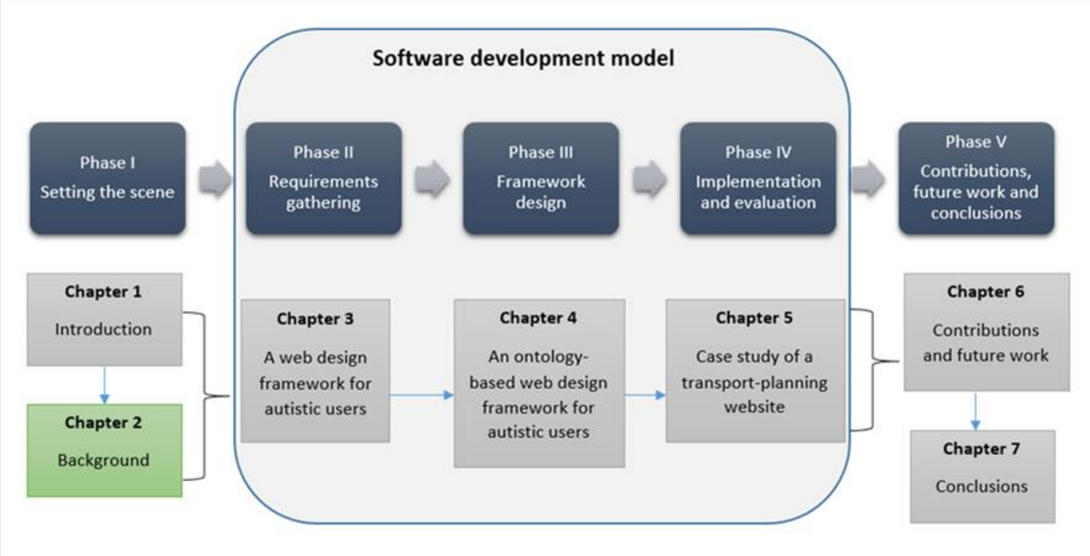


Figure 2.1 Chapter 2 in the context of the thesis structure

Phase I, setting the scene, ends with Chapter 2 as depicted in Figure 2.1. The background comprises an examination of the context of this thesis, the existing literature and related work, in order to get an overview of the range and depth of the research in the area of web interface design for autistic users. This chapter explains the different domains studied during the development of this thesis, namely: the autism condition, autistic users and the web, web accessibility, related studies about web interface design guidelines for autistic users, and the use of semantic web technologies as a tool for modelling the autism condition applied to web accessibility.

The principal domain of this research is web interface design and accessibility for autistic individuals. Therefore, it is important to start by explaining the autism condition, how this neurodevelopmental condition affects the way autistic people can access the Web and the implications on web accessibility for autistic users. Later, an explanation of semantic web technologies will be provided as well as a discussion of how ontologies, as part of the semantic web, can be used as a tool for personalisation and adaptation of web user interfaces. All domains are related and are sequentially developed in this thesis.

2.1 The autism condition

The autism condition is currently diagnosable using the classification of the Diagnostic and Statistical Manual of Mental Disorders fifth edition (DSM-5) by the American Psychiatric Association (APA) (American Psychiatric Association, 2013). According to the DSM-5 to be diagnosed with Autism Spectrum Disorder (ASD), an individual must present persistent deficits in social communication and social interactions and restrictive and repetitive patterns of behaviour (American Psychiatric Association, 2013). Autism is one of the neurodevelopmental conditions, i.e., a condition impacting the neurological system and the development of the brain (Thapar, Cooper, & Rutter, 2017), a group of lifelong conditions with onset in the developmental period of an individual. This conditions typically manifest early in development, often before the child begins school (Tager-Flusberg, Paul, & Lord, 2005).

2.1.1 Diagnosis and classifications

Autism spectrum disorder is diagnosed only when the characteristic deficits of social communication are accompanied by excessively repetitive behaviours, restricted interests and insistence on sameness (American Psychiatric Association, 2013). The autism diagnosis is made based on behavioural assessments about how the child talks and acts in comparison to other children of the same age (Tager-Flusberg et al., 2005); there is no medical test (blood tests or non-invasive technology) for autism. It is usually first diagnosed in childhood with many of the most-obvious signs presenting when the child is around 2–3 years old (Mandell, Novak, & Zubritsky, 2005), but some children develop typically until toddlerhood when they stop acquiring, or lose, previously gained skills (Rogers, 2004; Thurm, Manwaring, Luckenbaugh, Lord, & Swedo, 2014). The autism condition is also three to four times more common in boys than in girls, and many girls with the condition exhibit less obvious signs compared to boys (American Psychiatric Association, 2013).

Early diagnosis is essential for tailoring interventions and evidence-based treatments that have been widely documented to show better results and long-term outcomes for most individuals with the diagnosis (T. Falkmer, Anderson, Falkmer, & Horlin, 2013). The gold standard of diagnostic processes has been suggested to include a number of standardised assessments analysed by a suitably qualified multi-disciplinary team (Le Couteur, Haden, Hammal, & McConachie, 2008). However, all behavioural assessments are vulnerable to the issues of subjectivity and interpretive bias. (T. Falkmer et al., 2013).

There is a great range of abilities and characteristics of individuals with autism spectrum disorder – no two children appear or behave the same way. Consequently, the effects of ASD differ from person to person in regard to severity and combinations of symptoms (Daniels & Mandell, 2014). Indications can range from mild to severe and often change over time (American Psychiatric Association, 2013). DSM-IV categorised ASD in a number of specific sub-groups such as autism disorder, Asperger’s disorder, childhood disintegrative and diagnosis of a “pervasive developmental disorder not otherwise specified", but in the DSM-5 the sub-groups have been removed and were replaced with the diagnosis of ASD specifying the severity level of the condition based on the level of support that an individual requires. The APA has provided information about severity levels of ASD as presented in Table 2.1.

Table 2.1 Severity levels for Autism Spectrum Disorder according to DSM-5 by APA (American Psychiatric Association, 2013)

Severity level	Social communication	Restricted, repetitive behaviours
Level 3 "Requiring very substantial support"	Severe deficits in verbal and nonverbal social communication skills cause severe impairments in functioning, very limited initiation of social interactions, and minimal response to social overtures from others. For example, a person with few words of intelligible speech who rarely initiates interaction and, when he or she does, makes unusual approaches to meet needs only and responds to only very direct social approaches.	Inflexibility of behaviour, extreme difficulty coping with change, or other restricted/repetitive behaviours markedly interfere with functioning in all spheres. Great distress/difficulty changing focus or action.
Level 2 "Requiring substantial support"	Marked deficits in verbal and nonverbal social communication skills; social impairments apparent even with supports in place; limited initiation of social interactions; and reduced or abnormal responses to social overtures from others. For example, a person who speaks simple sentences, whose interaction is limited to narrow special interests, and who has markedly odd nonverbal communication.	Inflexibility of behaviour, difficulty coping with change, or other restricted/repetitive behaviours appear frequently enough to be obvious to the casual observer and interfere with functioning in a variety of contexts. Distress and/or difficulty changing focus or action.
Level 1 "Requiring support"	Without supports in place, deficits in social communication cause noticeable impairments. Difficulty initiating social interactions, and clear examples of atypical or unsuccessful responses to social overtures of others. May appear to have decreased interest in social interactions. For example, a person who is able to speak in full sentences and engages in communication but whose to-and-fro conversation with others fails, and whose attempts to make friends are odd and typically unsuccessful.	Inflexibility of behaviour causes significant interference with functioning in one or more contexts. Difficulty switching between activities. Problems of organisation and planning hamper independence.

Note: Adapted from American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders: DSM-5 (Fifth ed.): American Psychiatric Pub.

The International Classification of Functioning, Disability and Health (ICF) was created as a product of the revision of the International Classification of Impairments, Disabilities and Handicaps (ICIDH) of 1980. ICF is endorsed by the World Health Organization (WHO) and provides a comprehensive, internationally accepted nomenclature to describe health-related functioning in different conditions and condition groups, promoting an etiological-neutral perspective on disability (World Health Organization, 2007). It was officially endorsed by the WHO in 2001 as the international standard to describe and measure health and disability in the world population. The ICF framework is specifically designed to capture levels of the functional abilities and disabilities of both individual and general world population, and it is presented in a bio-psycho-social model of functioning (see Figure 2.2). The ICF allows for detailed classifications of functioning in the components of body functions and body structures, activities and participation. The bio-psycho-social model recognises that it is the interaction between health conditions, body functions and body structures, activities, participation and environmental and personal factors that determines an individual's level of functioning (World Health Organization, 2007).

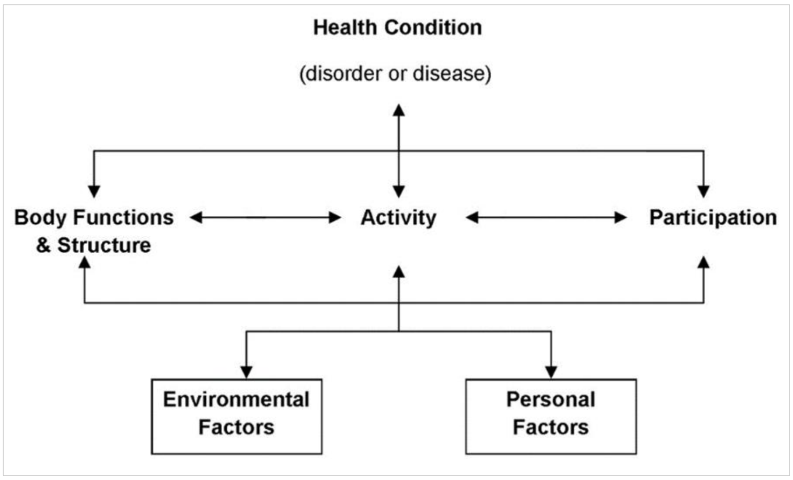


Figure 2.2 International Classification of Functioning Framework

The ICF includes 1685 categories which make it complicated to describe a specific level of functioning of an individual (Mahdi, Albertowski, et al., 2018). Thus, WHO has been working on developing ICF Core Sets with the aim to allow user-friendly and effective descriptions of health-related functioning by generating a shortlist of categories that are most relevant to a specific health condition, in the case of ASD the ICF Core Sets provide useful standards for research and clinical practice and generating a common language for functioning and impairment related to ASD in different areas of life and across the life span (Bölte et al., 2014).

The ICF Core Sets for ASD have been published after the conference consensus (Bölte et al., 2019) based on the official results from four preparatory studies: the systematic review (de Schipper et al., 2015), the expert survey (De Schipper et al., 2016), the patient and caregiver qualitative study (Mahdi, Viljoen, et al., 2018) and clinical cross-sectional study (Mahdi, Albertowski, et al., 2018). The core set comprises 111 second-level ICF categories - one body structure, 20 body functions, 59 activities and participation categories, and 31 environmental factors, and demonstrated that body structures and functions are not as relevant as the daily living and functioning in various environments in the determination of functioning levels of individuals with ASD (Bölte et al., 2019).

2.1.2 Autism strengths and difficulties

An individual with an ASD diagnosis has specific characteristics and depending on environmental and personal factors, these may result in restrictions in activities and/or participation according to the ICF framework (Mahdi, Albertowski, et al., 2018). Results from an international clinical study of ability and disability in ASD show that the most frequently reported co-morbidities of autistic individuals were Attention deficit hyperactivity disorder (ADHD), intellectual disability, depression, specific developmental disorder of motor function, and generalised anxiety disorder (Mahdi, Albertowski, et al., 2018).

Results of the ICF Core Sets for ASD corroborated previous research findings that the most frequently reported strengths are memory functions, directing attention and attention functions. Abilities such as attention to details and focus, combined with a willingness to engage in repetitive tasks, can be advantageous for work output as it may benefit workplaces that focus on tasks that require these characteristics to accomplish them (Mahdi, Albertowski, et al., 2018). Based on research to date, the autism profile has been found to excel in attention to detail, enhanced visuospatial skills, creativity, concentration, fine detail processing and memory (Mahdi, Albertowski, et al., 2018).

From the same study, it was conclusive that the most prevalent ASD-related difficulties are communication skills, social interaction, self-care, domestic life and fulfilling general tasks and demands. The level of intellectual functioning of autistic individuals varies enormously, ranging from profound impairment to superior non-verbal cognitive skills (American Psychiatric Association, 2014). It is estimated that between

30% and 50% of people diagnosed with the autism condition never develop appropriate speech for conversation (Davis III et al., 2011). It is common for children and adults with an autism diagnosis to struggle with social interactions because they have difficulties deciphering how to relate with others, as explained by the theory of mind theory (Frith & Happé, 1994), which refers to the ability to understand that others and oneself have beliefs, desires, intentions, and perspectives that could be different from one's own (Baron-Cohen, 2001). Another theory explaining related difficulties is the weak central coherence theory. This theory proposes that autistic individuals are frequently biased towards processing local sensory information with less account for global, contextual and semantic information (Frith & Happé, 1994). The weak central coherence is strongly related to the capacity to focus more on details than on the big picture, a tendency known as stimulus over selectivity (Lovaas, Koegel, & Schreibman, 1979).

Autistic individuals have communications issues characterised by difficulty in using language for social purposes, appropriately matching communication to social context, following rules of communication context (e.g., back and forth of conversation), understanding nonliteral language (e.g., jokes, idioms, metaphors) and integrating language with nonverbal communicative behaviours (Fairweather & Trewin, 2010; Swineford, Thurm, Baird, Wetherby, & Swedo, 2014). Also, many autistic individuals experience sensory issues related to sound, light, touch and smell provoking atypical responses that can cause frustration and disturbance (Case-Smith, Weaver, & Fristad, 2015). Anxiety is also more commonly diagnosed in autistic than non-autistic people, causing nervousness, fear, apprehension, and worrying about a strong desire or concern to do something, or for something to happen (Davis III et al., 2011).

The prevalence of autism worldwide is 1-2% (Mahdi, Albertowski, et al., 2018). According to the Survey of Disability, Ageing and Carers 2015 (SDAC), an estimate of 164,000 Australians (0.5%) have the diagnosis, representing about 1 in 150 people. In 2014–15, around 43,500 autistic people accessed disability support services under the Australian National Disability Agreement, and over the next 10 years this number is expected to reach 181,000 as the prevalence of this diagnosis is increasing due to new diagnosis tools and more recognition under the public health system in Australia (Australian Bureau of Statistics, 2012). In the United States the prevalence of autism, as studied in 11 sites of The Autism and Developmental Disabilities Monitoring Network, increased 29% from 2008 to 2010, with 1 in 68 children (aged 8 years) diagnosed with autism (Baio, 2014).

2.2 Web accessibility

2.2.1 Introduction to web interface design

The beginnings of web interface design go back to the human-computer interaction since the first interface was created back in 1973 when Xerox PARC developed the Alto personal computer. It incorporated a bitmapped screen and was the first computer to demonstrate the desktop metaphor and a graphical user interface (Thacker, MacCreight, & Lampson, 1979). Since then, a lot has changed in user interfaces, allowing users to interact intuitively with computers and facilitating an understanding of different components despite the specific web design styles of each website or web product.

Web design encompasses three different disciplines in the production and maintenance of websites (Garrett, 2002). They are:

- Web graphic design – referring to visual communication and communication design.
- Interface design – referring to how the graphic elements will be presented on different platforms such as laptops, smartphones or tablets.
- User experience – referring to how a design will make its audience feel and react (Garrett, 2002; International Organization for Standardization ISO, 2018; Nielsen & Loranger, 2006). User experience combines web graphic design and interface design (Garrett, 2002).

The user experience is highly related to web usability as declared by usability expert Jakob Nielsen (Nielsen & Loranger, 2006). Usability has become more important than ever as users become less tolerant of difficult sites.

Consequently, aiming for good user experience and web usability inevitably requires high understanding of user needs and correct use of the different elements of a user interface (Garrett, 2002). Designers and web developers have the difficult task of designing human-computer systems for many different kinds of users, with the overall goal that each system fulfil the requirements of good user experience and web usability for all users (Abascal & Nicolle, 2005).

2.2.2 Web interface design standard and guidelines

A guideline is a statement aiming to guide decisions and criteria to determine a course of action (Cambridge Dictionary, 2019). Therefore, web interface design guidelines are developed to create a common base for web developers, software developers and people responsible for creating digital content (W3C, 2016). These guidelines for web design are statements that aim to help making websites more accessible, usable and understandable (Szigeti, 2012). Web design guidelines can be found in literature such as open-access reports, qualitative and quantitative studies and in international standards (Al-Badi et al., 2012).

The international standards for web design are primarily documented by two of the main international standards organisations for the Internet; International Organization for Standardization (ISO) and the World Wide Web Consortium (W3C) (W3C, 2016).

The W3C created the Web Accessibility Initiative (WAI), which publishes the Web Content Accessibility Guidelines (WCAG) (W3C, 2019d) promoting that web technology should be accessible to all people, especially people with disabilities. They support making the Web accessible, independent of hardware, software, language, culture, location, or users' physical or mental ability (W3C, 2016). Guidelines published by WAI are greatly accepted because they are created by a consortium comprising a heterogeneous team of people from institutions, academia and industry. Before their acceptance by the group, the guidelines follow a careful process of proposal and revisions, leading this process to a healthy consensus which enhances the universal acceptance of the results (Abascal & Nicolle, 2005).

The first version of WCAG, version 1.0, was published in 1999, followed by version 2.0 introduced on 11 December 2008. The current version, WCAG 2.1, was published on 5 June 2018 (W3C, 2019d). Any website that conforms to WCAG 2.1 is also compliant with WCAG 2.0; the W3C encourages web developers to use the most recent version of WCAG when developing or updating content or accessibility policies. WCAG is the most recognised web accessibility standard in the world and many countries have adopted it in their legislation to protect the right to access the Web for all people (European Parliament, 2014; Government of Canada, 2011; U.S. Access Board, 2017). In Australia, it is recognised by the Human Rights Commission (Australian Human Rights Commission, 2014).

The WCAG standard version 2.0 was created as ISO standard ISO/IEC 40500:2012 (W3C) in 2012 (International Organization for Standardization ISO, 2012). The ISO standards covering the web user experience are:

- ISO 9241: Ergonomics of human-computer interaction (Formerly ISO 13407:1999 – Human-centred design processes for interactive systems).
- ISO 9241-210:2010 – Human-Centred Design for Interactive Systems (Formerly ISO 13407:1999).

- ISO 9241-171:2008 – Guidance on Software Accessibility (Formerly ISO/TS 16071:2003). This standard is broad and covers all software, not just the Web.
- ISO 9241-11:2018 – Usability: Definitions and concepts which defines usability as “the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” (International Organization for Standardization ISO, 2018).

For many years, ISO and WCAG guidelines were focused on addressing web accessibility for users with physical, visual and sensory disabilities (Poulson & Nicolle, 2004) while much remained to be done for people with different neurodevelopmental conditions such as autism. The reason for this may be due to the difficulty of addressing the variety of needs specific to autistic people (Friedman & Nelson Bryen, 2007), a lack of experience working with accessibility (Schmutz et al., 2016), and the fact that development of web accessibility has mainly been focused on visually impaired users (Britto & Pizzolato, 2016). Another reason may be that although ISO and WCAG guidelines are straightforward enough, in practice they can be somewhat limited, and difficult to implement for web developers (Poulson & Nicolle, 2004) who are often trained to deal with usability issues but not necessarily accessibility issues (Loiacono & Djamasbi, 2013). Szigeti (2012) demonstrated that web design guidelines were often inconsistently interpreted by web developers, which represents a critical problem in guideline use.

2.2.3 Web accessibility for people with cognitive disabilities

As part of the Web Content Accessibility Guidelines (WCAG), the W3C has been trying to bridge the accessibility gap for people with learning and cognitive disabilities when using the Web and information technologies. They created The Cognitive and Learning Disabilities Accessibility Task Force (COGA TF), as part of the Cognitive Accessibility User Research (W3C, 2015). They recognised that these groups presented challenges in the areas of attention, executive function, knowledge, language, literacy, memory, perception and reasoning. In order to meet these challenges, they organised user groups of the following conditions to help them more deeply analyse their needs: Aging-Related Cognitive Decline, Aphasia, Attention Deficit Hyperactivity Disorder, Autism, Down syndrome, Dyscalculia, Dyslexia and Non-Verbal.

As a result, the COGA TF performed a gap analysis, suggested techniques, and created a road map for improving accessibility for people with learning and cognitive disabilities. They concluded that people with cognitive disabilities may have problems in the following areas:

- Memory – including: working memory, short-term memory, long-term memory, visual memory, visuospatial memory and auditory memory (memory for sound patterns and others).
- Executive functions – including: emotional control and self-monitoring; planning, organisation and execution; and judgment.
- Reasoning – including: fluid reasoning (logical reasoning), mathematical intelligence, seriation, crystallised intelligence and abstraction.
- Attention – including: selective attention and sustained attention.
- Language – including: speech perception, auditory discrimination, naming skills and morphosyntax.
- Understanding figurative language – including: similes, personification, oxymorons, idioms and puns.
- Literacy – (depending upon functions) including: speech perception, visual perception, phoneme processing and cross-modal association (association of sign and concept).
- Other perception – including: motor perception and psychomotor perception.
- Knowledge – including: cultural knowledge, jargon (subject matter), web jargon and technology, metaphors and idioms, symbols knowledge (such as icons) and mathematical knowledge.
- Behavioural – including: understanding social cues.

The problems vary in each person, and even if two people share the same diagnosis they can behave very differently. For example, a person with dyslexia may have above-average reasoning, but impaired visual memory and literacy skills. A person with Down Syndrome may have an above-average visual memory, but impaired judgment (W3C, 2015).

Furthermore, the COGA TF group also published the Cognitive Accessibility Roadmap and Gap Analysis (W3C, 2019a) that presents practical recommendations and resources with the aim of meeting the needs of web developers, content creators and policymakers so they can make content usable for people with learning and cognitive disabilities. In these recommendations, they used the “persona” concept: “Personas” are not real people, but they represent them through a design process. They are hypothetical archetypes of real users (Cooper, 2004). A “persona” is a fictional character created to represent a user type that might use a site, brand or product in a similar way (Lidwell, 2010). The COGA TF group created a “persona” with an autism diagnosis (W3C, 2019c) to help explain some challenges they might face when interacting with websites by providing the following examples: coping with poor layouts and illogical navigation, changing colour schemes, flashing, blinking and automatic playing videos or music, and designs that make use of abstract imagery and metaphors.

2.2.4 Autistic users and the Web

People with neurodevelopmental conditions such as autism are likely to have problems learning how to use the software, remembering instructions and understanding how to navigate the Web (Friedman & Nelson Bryen, 2007; Pavlov, 2014). This is because their limited working memory negatively affects the required cognitive load to navigate webpages that are overly complex in structure and content (Mejia-Figueroa, Quezada Cisnero, & Juarez-Ramirez, 2016), making accessing the Web by those with neurodevelopmental conditions particularly difficult (Darejeh & Singh, 2013; Poulson & Nicolle, 2004).

Several studies have found that autistic users tend to navigate websites in a different style and order from non-autistic users (Matthews et al., 2019; V. Yaneva, An Ha, Eraslan, Yesilada, & Mitkov, 2018). Autistic individuals with different levels of cognitive functioning use web interfaces in different ways and have different results when accomplishing search tasks (Mejía-Figueroa & Juárez-Ramírez, 2015; Mejia-Figueroa et al., 2016). In addition, several other studies have declared that autistic users have specific needs when interacting with computers (Goodwin, 2008; Kamaruzaman, Rani, Nor, & Azahari, 2016; S. Karim & Tjoa, 2006; Pavlov, 2014; Sula et al., 2013). For instance, autistic users prefer reduced visual complexity and simple language along with multimedia tools such as audio and images (Eraslan et al., 2018; Grynszpan, Martin, & Nadel, 2008). Furthermore, as presented by Friedman and Nelson Bryen (2007), some of the top web design recommendations for autistic users include the use of pictures, icons and symbols along with text, consistent navigation and design on every page, and uncluttered, simple screen layout.

Websites should optimally be able to facilitate the interaction for autistic users but sometimes they are not easily adapted for complex and multiple requirements, and consequently, might be perceived as being difficult to use (Kimball & Smith, 2007; Mejía-Figueroa & Juárez-Ramírez, 2015). Exposed by Poulson and Nicolle (2004), there is a lack of adapted web browsers and integration with current Alternative and Augmentative Communication (AAC) to help making the web accessible for people with cognitive and communication conditions. They also presented that the most important needs for autistic users when navigating the Web were a good screen reader, guidance for text in speech synthesisers and entering URLs, guidance for add-ons and plug-ins, navigation awareness (where they have been, where they are, where they can go) and prevalence of symbols over text.

When autistic users used software for learning purposes, two main problems were frequent as reported by Kimball et al. (2007). Firstly, few programs are made or tested by autistic users, so these programs had several pedagogical failures. And secondly, software made for learning proposes should be entertaining and most pedagogical software lacks this feature. Furthermore, Davis et al. (2010) developed a software package called TouchStory with the aim of promoting comprehension of narrative modes of thought to improve social understanding. They found that autistic users preferred predictable, structured and controlled procedures and environments, as they were visual learners and thinkers. They also found that failing to achieve a goal was very debilitating and that all unnecessary sounds or animations should be avoided.

Based on previous research, Quezada et al. (2017) identified that the easiest operations to perform on user interfaces for autistic users were keystroke, drag, initial act and tapping. The use of keyboard and dragging activities were highly recommended, while activities that need decision making and create high cognitive load were suggested to be avoided.

Furthermore, according to a study using eye-tracking to explore visual fixations while performing a web searching tasks, autistic users tended to focus on more elements and make more transitions between elements compared with non-autistic users (Eraslan et al., 2018). Autistic users also tended to make shorter and more frequent fixations on web elements that were not related to a given search task compared to their non-autistic peers (V. Yaneva et al., 2018).

To explore the research domain of web accessibility for autistic users, the strategy was to do a background check about the domain which concluded with the identification of a copious number of web interface design studies and guidelines (Britto & Pizzolato, 2016; Dattolo & Luccio, 2017; Davis et al., 2010; Dekelver et al., 2015; Elias et al., 2016; Friedman & Nelson Bryen, 2007; Government of Canada, 2011; Mejía-Figueroa & Juárez-Ramírez, 2015; Pavlov, 2014; Schmutz et al., 2016; W3C, 2019a, 2019d). Hence, to further analyse and report the findings on this domain, a scoping review, a focus group and an affinity diagram method were conducted and their results and analysis are presented in Chapter 3 as the requirements gathering process to discover the web design accessibility guidelines to create accessible websites for users on the autism spectrum.

2.3 User modelling for web adaptations

User models can help by determining the characteristics of the user and how they affect the design of the software (Mejía-Figueroa & Juárez-Ramírez, 2013). Services that are personalised according to the individual that is going to use them positively increases user satisfaction (J. Hussain et al., 2018). This is one of the reasons that user modelling research has shown great benefits for web designers and developers when writing software to be usable, useful and learnable for the majority of users (Fischer, 2001).

Web personalisation occurs when the interface is adapted to the user's needs and preferences during the interaction with the interface, but to make this possible, web developers need to understand the user's needs during the planning and design stages. This means that when the user interacts with the web interface, it had been previously coded to be properly adapted to its user (Fischer, 2001). Web developers use user-modelling and the *Persona* concept during design-time to model the characteristics of their potential users who can, therefore, have a good user experience during run-time (Garrett, 2002).

One approach using autism-modelling to create a web adaptation explained that based on the executive functions of an autistic individual an architecture of three parts could be developed (Mejía-Figueroa & Juárez-Ramírez, 2015): the user model, the domain model and the adaptive mechanism. Executive functions are the ones in charge of the cognitive processes used to accomplish oriented tasks. Mejia-Figueroa and Juarez-Ramirez (2015) identified that the autism condition has several common traits and characteristics that can have a direct effect on how autistic users interact with user interfaces. They divided those traits and characteristics into primary and secondary attributes. Primary attributes refer to the mental maturity, motor skills, verbal comprehension, perceptual reasoning, working memory, processing speed, vision and hearing senses, education level, learning style and language. The secondary attributes refer to gender and physical age, country of origin and religion, and experience with similar devices and software. It was concluded that there is a significant relationship between usability results of design patterns and the measurements of working memory and cognitive flexibility, and the perceived cognitive load produced by the pattern upon the users. It demonstrates that web design requiring less executive function (working memory and cognitive flexibility), reduces the problem of user's cognitive load on graphical user interfaces (Mejia-Figueroa & Juárez-Ramírez, 2017) and improves the user experience for autistic users.

In conclusion, autistic users have needs and preferences that should be translated into user interface adaptations. Software design based on the concept of user-model links to the use of semantic web technologies as a solution to model and manage the needs, strengths and limitations of autistic users when navigating desktop websites.

2.4 Semantic web technologies

The core programming language for the World Wide Web (WWW) is the Hypertext Markup Language (HTML) developed by the WWW Consortium (W3C). Together with Cascading Style Sheets (CSS) and JavaScript, it is the main technology to create websites and applications. The technology used to develop websites has been evolving from static HTML to more advanced techniques and tools, and with the aim to integrate data and allow semantic integrations, "ontologies" were created (Berners-Lee, 2006).

2.4.1 Ontology-based technology

In the context of computer science, ontologies are the formal representation of knowledge including the concepts within a domain and the relationships between those concepts (Genesereth & Nilsson, 1987; Gruber, 1993). In more detail, ontologies are explicit, formalised and shared specification of the conceptualisation. By "explicit" it means that the concepts used and the restrictions applied to them are clearly defined. By "formalised" it means that a machine can process it. By "shared" it means that the knowledge acquired is a consensus of experts in the field. Conceptualisation is understood to be an abstract and simplified version of the world to be represented: a representation of knowledge based on objects, concepts and entities existing within the studied area, as well as the relationships existing among them, being in this research the domain of web accessibility for autistic users (Ruiz & Hilera, 2006). An ontology defines a common vocabulary to share information in a domain (Noy & McGuinness, 2001). It includes machine-interpretable definitions of basic concepts in the domain and relations between them. Ontologies support the annotation and integration of scientific data, allowing semantic integrations. The ability to exchange information between different applications means that the information may be made available to applications other than those for which it was originally created (W3C, 2014). An ontology must be able to answer natural language sentences, with "natural language" meaning day-to-day human language within a domain of expertise. These sentences are expressed as competency questions which are typical queries that an expert might want to submit to a knowledge base of a target domain (Gangemi & Presutti, 2009; Grüninger & Fox, 1995).

The resources described by ontologies are "individuals" (instances), "classes" (concepts), attributes and relations (Allemang & Hendler, 2011). Those resources can be anything from real word entities to abstract concepts (W3C, 2014). Ontology Web Language (OWL) is the family of representational languages that describe an ontology. It is the official language for defining ontologies on the web. OWL is a vocabulary extension of the Resource Description Framework (RDF) to model knowledge (Bechhofer, 2009). RDF is intended for situations in which information on the Web needs to be processed by applications, rather than being only displayed to people (W3C, 2014).

Resource Description Framework statements

The RDF statement is a triple set of resource (subject), property (predicate) and value (object), where the predicate expresses the relationship between the subject and the object. The relationship is phrased in a directional way (from subject to object) and is called in RDF a property. A simple expression is:

```
<Claudia><is-a><Person>
```

The resources 'Claudia' and 'Person' have a relation of 'is-a'.

Each resource must be unique and use a Uniform Resource Indicator (URI), which is a generalisation of the Uniform Resource Locator (URL) – its global name on the Web. Continuing the example expressed with the use of Internationalized Resource Identifiers (IRIs), it will be:

```
<http://example.com/Claudia>
<http://example.com/is-a>
<http://example.com/Person>
```

An RDF graph is a mental model for RDF statements. Following the previous example, the graph would be as presented as follows in Figure 2.3.

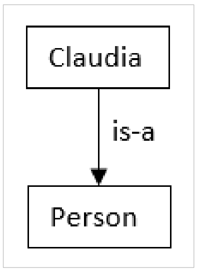


Figure 2.3 Resource Description Framework (RDF) graph example

Prefixes are used to allow the domain name of an IRI to be abbreviated for better readability. For example, if the URL http://example.com/ is abbreviated to 'ex', any resource with that URI can be abbreviated with that prefix. For example, http://example.com/Claudia can be abbreviated to ex:Claudia).

The programming language RDF Schema uses the notion of class to specific categories that can be used to classify resources. A class can have subclasses that represent concepts that are more specific (Noy & McGuinness, 2001). The relation between an instance and its class is stated through the type property. With RDF Schema one can create hierarchies of classes and sub-classes and of properties and sub-properties. Type restrictions on the subjects and objects of particular triples can be defined through domain and range restrictions (W3C, 2014).

Namespaces

A namespace is a unique URI. The World Wide Web Consortium W3C has defined a number of standard namespaces for use with Web technologies providing vocabulary definitions of terms used to express resources (Allemang & Hendler, 2011):

rdf: indicates identifiers used in RDF. The set of identifiers defined in the standard is used to define types and properties in RDF. The global URI for the rdf namespace is http://www.w3.org/1999/02/22-rdf-syntax-ns#

rdfs: indicates identifiers used for the RDF Schema language, RDFS. The global URI for the rdfs namespace is http://www.w3.org/2000/01/rdf-schema#

owl: Indicates identifiers used for the Web Ontology Language, OWL. The global URI for the owl namespace is http://www.w3.org/2002/07/owl#

Expressing RDF data

Different syntax and file formats can be found in the market to express RDF data. The most common are N-Triples (.nt), Turtle (.ttl), JSON-LD (.json) or RDF/XML (.rdf), and all are supported by the main RDF libraries and triplestores. The personal preference of the author is the Turtle (ttl) format as it is commonly used between developers, and it is outlined in relevant books for programming the semantic web and has plenty of online support.

The ttl syntax provides for a compact representation of triple data. It begins with the first triple in subject/predicate/object order terminating with a period for single triple or a semicolon to indicate that another triple with the same subject follows. For that triple, only the predicate and object need to be specified (since it is the same subject as before). These examples are created and further explained by (Allemang & Hendler, 2011).

Single triple in Turtle ttl:

```
Prefix mfg:
<http://www.WorkingOntologist.com/Examples/Chapter3/Manufacturing#>
 @prefix rdf: http://www.w3.org/1999/02/22-rdf-syntax-ns#
mfg:Product1 rdf:type mfg:Product .
```

Multiple triple in ttl:

```
mfg:Product1 rdf:type mfg:Product;
mfg:Product_Division “Manufacturing support”;
mfg:Product_ID “1”;
mfg:Product_Available “23” .
mfg:Product2 rdf:type mfg:Product;
mfg:Product_Division “Manufacturing support”;
mfg:Product_ID “2”;
mfg:Product_Available “4” .
```

Turtle provides a compact way to express several triples that share both subject and predicate. Turtle uses a comma (,) to separate the objects. So the fact that Shakespeare had three children named Susanna, Judith and Hamnet can be expressed as follows:

```
lit:Shakespeare b:hasChild b:Susanna, b:Judith, b:Hamnet.
```

Commonly used vocabularies

One of the first RDF vocabularies used worldwide was the "Friend of a Friend" (FOAF) vocabulary for describing social networks. Other examples of RDF vocabularies are Dublin Core, schema.org and SKOS (Allemang & Hendler, 2011).

Dublin Core

The Dublin Core Metadata Initiative (Dublin Core Metadata Initiative DCMI, 2019) maintains a metadata element set for describing a wide range of resources. The vocabulary provides properties such as "creator", "publisher" and "title".

schema.org

Schema.org (Schema.com, 2019) is a vocabulary developed by a group of major search providers. The idea is that webmasters can use these terms to mark-up web pages so that search engines understand what the pages are about.

SKOS

SKOS is a vocabulary for publishing classification schemes such as terminologies and thesauri on the Web. SKOS has been recommended by W3C since 2009 and is widely used in the library world.

Query and rules-language

The predominant query language for RDF graphs is SPARQL. SPARQL is a set of specifications that provide languages and protocols to query and manipulate RDF graph content on the Web or in an RDF store. The Semantic Web Rule Language (SWRL) is a proposed language for the Semantic Web that can be used to express rules as well as logic (Horrocks et al., 2004).

2.4.2 Autism and related ontologies

Studies have modelled users with disabilities and different conditions as they interact with information technology (E. Castillejo, A. Almeida, & D. López-de-Ipiña, 2014; Fischer, 2001; J. Hussain et al., 2018; Mejía-Figueroa & Juárez-Ramírez, 2015; Shahzad, Granitzer, & Tochterman, 2009). To date, the author has not been able to identify any studies exploring the interaction of the user with information technology based on modelling of autistic users.

As previously mentioned, the International Classification of Functioning, Disability and Health (ICF) (World Health Organization, 2007) provides a unified and standardised language and a conceptual framework to describe health and health-related states. It has been proposed that the ICF classification can be used to model the interaction between humans and devices within the context of the information society (Billi, Burzagli, Emiliani, Gabbanini, & Graziani, 2006). In 2006, the model presented by Billi et al. (2006) proposed three extensions of ICF needed to describe the user, the characteristics of the interaction required and the context of use. Following the same approach as Billi et al., and using a test case of ontologies of impairments and user interfaces, Karim and Tjoa (2007) presented a model in the domain of a hospital and demonstrated that the users' disabilities and capabilities could be used to modify their user interfaces. Later, other studies continued this approach and created different products where the users' limitations and symptoms were modelled (García-Betances, Cabrera-Umpiérrez, Ottaviano, Pastorino, & Arredondo, 2016; S. Karim & Tjoa, 2006; M. Kultsova, Potseluico, Anikin, & Romanenko, 2016; Marina Kultsova, Potseluico, Zhukova, Skorikov, & Romanenko, 2017).

One of the most recent approaches linking user modelling and user interfaces is the ontology integration based on activity-centred design implemented by Romero-Marino et al. (2018). The ontology is called ACCESIBILITIC with the primary objective of modelling the functional diversity of users. It focused on users' capabilities more than on users' limitations. It aimed firstly to characterise assistive devices and software tools used to support accessibility, secondly to model the user's interaction taking into account capabilities, disabilities, devices and software tools, and thirdly to characterise the user's participation in daily life activities using information technologies based on the activity-centred design.

The autism condition was initially modelled as an ontology by the National Database for Autism Research (NDAR) (http://ndar.nih.gov/). The goal of NDAR is to provide investigators with a public resource for collecting, archiving, retrieving, sharing and analysing data on autism (Tu et al., 2008). McCray et al. (2014) expanded the NDAR autism ontology (Tu et al., 2008) including three main classes: personal traits, social competence and medical history (Figure 2.4).

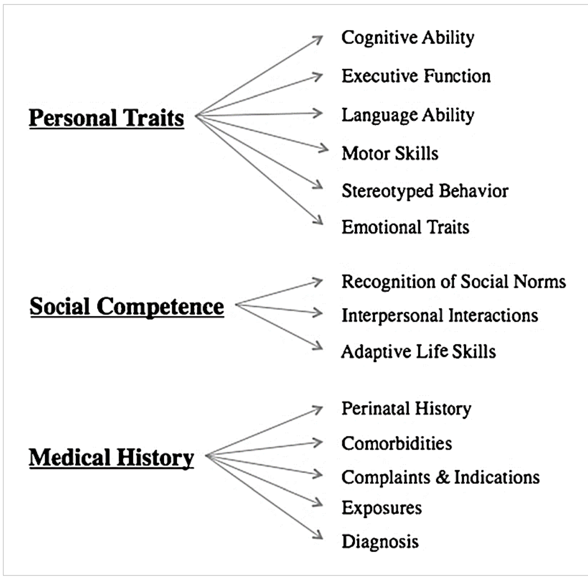


Figure 2.4 Autism Ontology by McCray et al. (2014)

This ontology holds 34 classes representing phenotypes, and four classes representing autism diagnostic instruments such as interviews (for example: Autism diagnostic interview–revised, symptom checklist, vineland adaptive behaviour scales, second edition), direct assessments (such as: Autism diagnostic observation schedule (ADOS-1–ADOS −4), broader phenotype autism symptom scale, clinical evaluation of language fundamentals (CELF, CELF-4RF1, CELF4RF2, CELF-2), among others), and questionnaire (such as: Brief rating inventory of executive function BRIEF, and Children's communication checklist CCC-2, among others). Additionally, the ontology includes a set of 15 Semantic Web Rule Language (SWRL) rules that allow the inference of certain phenotypes for a given patient based on data from the represented autism diagnostic instruments. For example, a researcher can query the database for all individuals who have severe deficits in executive function and then can correlate the results with the genetic analysis for those individuals.

Later, the autism ontology created by McCray et al. (2014) was expanded with more relationships and definitions by Mugzach et al. (2015). It was created to infer autism phenotypes based on the Autism Diagnostic Interview-Revised (ADI-R) assessment data. The results included 443 new classes and 632 rules. Additionally, this expanded ontology includes the DSM-5 diagnostic criteria, and by adding knowledge of related neurodevelopmental disorders, commonalities and differences in manifestations and risk factors, autism could be automatically inferred, contributing to the understanding of the autism pathophysiology.

2.5 Summary

This chapter presented the background of the research, explaining the autism condition, the web accessibility concept and current guidelines, explained the user modelling for web adaptations and ended explaining the semantic web technologies. Chapter 3 presents the second phase of this thesis as the requirements gathering to create a web design framework for autistic users.

Chapter 3 A web design framework for autistic users

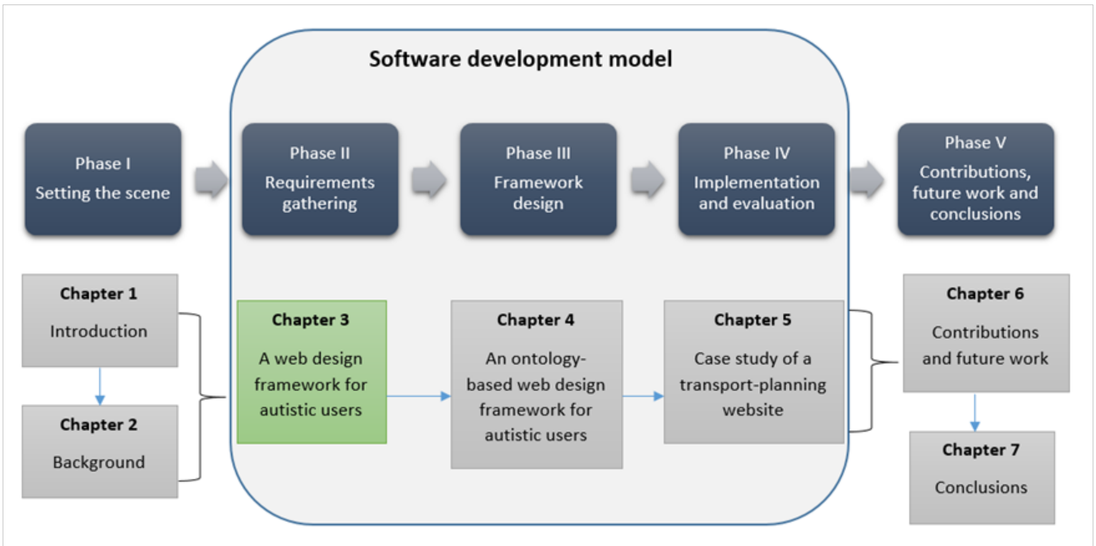


Figure 3.1 Chapter 3 in the context of the thesis structure

This chapter is aligned with Phase II of the research, the requirements gathering, and focuses on developing a unified web design framework for autistic users by identifying the key design elements and accessibility features for their use and understanding of desktop websites. This Chapter in the context of the whole thesis is presented in Figure 3.1. The web interface design principles identified in this study will be modelled as a software design in Chapter 4, and the software model will be implemented and evaluated in a case study in Chapter 5.

As noted in the last chapter, there are currently a myriad sources of web accessibility standards and web interface design guidelines that web developers and web content creators have to understand and adopt into their work. This is potentially confusing and may cause uncertainty in how standards and guidelines are/should be interpreted and implemented.

To address this problem, a three-phase process (Figure 3.2) was initiated to capture the existing body of knowledge of web design standards and guidelines for autistic users.

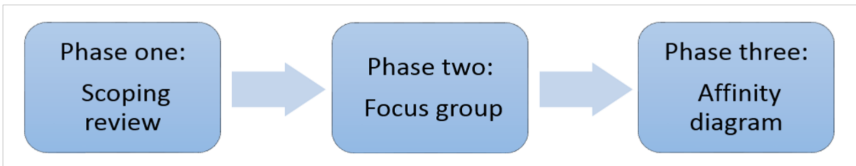


Figure 3.2 Three-phase process

Firstly, a scoping review was conducted to explore current web design guidelines and recommendations for autistic users. Secondly, the literature was summarised and brought to a focus group in order to allow the participants to discuss it in a validation process.

Thirdly, an affinity diagram (McConnell, 1992) was used to obtain a list of final web interface design guidelines for autistic users. These results are presented as a general framework representing the guidelines, best practices, tools and general recommendations for creating accessible desktop websites for autistic users.

3.1 Scoping review

3.1.1 Method

The purpose of a scoping review is to map the literature on a particular topic or research area and provide an opportunity to identify key concepts, gaps in the research, and types and sources of evidence to inform practice, policymaking and research (Daudt, van Mossel, & Scott, 2013). The strategy for the scoping review in this thesis was based on the framework outlined by Arksey and O'Malley (2005) comprising six stages (Table 3.1).

Table 3.1 Scoping review process

Stage	Description
Stage 1	Identifying the research question
Stage 2	Identifying relevant studies
Stage 3	Selection of terminology and inclusion criteria
Stage 4	Charting the data
Stage 5	Collating, summarising and reporting the results
Stage 6	(Optional) Consultation exercise

Note. Adapted from Arksey, H. and L. O'Malley, *Scoping studies: towards a methodological framework.* International Journal of Social Research Methodology, 2005. **8**(1): p. 19-32. Copyright 2005 by Taylor and Francis Group Ltd.

3.1.1.1 Stage 1: Identifying the research question

The research question was: *What is currently known about web interface design standards and guidelines specific for autistic users?*

Responding to this question required an analysis of: how many studies have published web interface guidelines for autistic users? How the guidelines were grouped or informed? How the target users were referred to? What was the source of information?

The research question had different aspects or facets to consider given the synonyms and different terminology used in defining software elements. For example, “web interface design” can be referred to as user interface design, human–computer interaction, or software design. “Guidelines” can be found as recommendations or best practices.

"Autistic" users can be described as users with autism or cognitive impairment, or special need users. The inclusion and awareness of these parameters were relevant in order to include as many studies and references as possible, reducing the likelihood of missing relevant studies during the search process.

3.1.1.2 Stage 2: Identifying relevant studies

The searching strategy of identifying relevant studies included the review of electronic databases and reference-lists. The literature was searched using electronic databases such as Scopus (https://www.scopus.com/), Web of Science (All databases) (http://login.webofknowledge.com/), ProQuest (https://www.proquest.com/), PsycINFO (Ovid) (https://www.apa.org/pubs/databases/psycinfo/). These databases were selected as they are comprehensive and cover a broad range of disciplines.

The search query was tailored to titles, abstracts and study-keywords of peer-reviewed English publications from the earliest database records to their most recent publication in December 2018. Search terms used were grouped in relation to: (1) software category, (2) recommendation and (3) diagnosis (Table 3.2). Combinations of search terms were identified, truncated, exploded and adjusted for optimal results. For example: web guidelines are also called "accessibility guidelines", "accessibility recommendations", or "user interface design principles". Numerous authors have broadened their studies for autistic users as web guidelines or recommendations for users with neurodevelopmental conditions, special needs or cognitively impaired users. As autism is considered as part of these groups, related terminologies were also included in the search criteria.

Table 3.2 Search terminology used in the scoping review

Software category	Recommendation	Diagnosis
Web*, web design, user interface, interface*, software, application, web accessib*, interface design	Web standard*, guideline*, recommendation*, best practise*, usability	autis*, asperger*, neurodevelopmental condition*, cognit* impair*, special need*

* Search terms truncated and exploded.

The reference-list check process was another valuable source of relevant publications. The strategy was to check the reference list of the most relevant studies found through the databases search. The most relevant studies were identified when the title or abstract included more than three keywords contained in the search terminology.

Citations were exported to Microsoft Excel software matching the headings from the different sources of information to the following dataset: Database name, Author(s) name, Publication title, Year of publication and abstract.

3.1.1.3 Stage 3: Studies selection

The initial electronic databases search and reference-list check identified a large number of studies, hence the search needed to be refined applying inclusion and exclusion criteria. A study was considered to be included in the current scoping review if it complied with any of the following criteria:

- The publication corresponded to a web standard, i.e., ISO (International Organization for Standardization ISO, 2012) and WCAG (W3C, 2019d).
- It was a peer-reviewed publication from conference proceedings, scientific journals, or books.

The exclusion criteria were:

- Works that were cited in studies that had synthesised their web design recommendations or guidelines and the master-document was already included.
- When the same data were reported in more than one publication, i.e., in conference proceedings and as a journal article, only the article reporting the most complete data set was included.
- Works where the web design recommendations or guidelines were provided for the general population and were not mentioned being developed for autistic users, neurodevelopmental conditions, or cognitive impaired user.
- Works related to web design or accessibility for non-desktop interfaces such as 3D interfaces, robotics and Internet of Things. Mobile and tablet related guidelines were analysed and included if the described web design guideline or recommendation applied to desktop websites.

Duplicate citations were removed manually and further duplicates were removed when they were found later in the process. Subsequent title and abstract relevance screening were conducted and non-relevant records were excluded.

3.1.1.4 Stage 4: Charting the data

Data characterisation of full articles was conducted to facilitate the comparisons between different studies. Later, data synthesising and interpreting were performed to sort the material according to key issues and themes.

Complementing the information already exported by each publication (Database name, Author(s) name, Publication title, Year of publication and abstract), the following numerical and descriptive data were charted when the information was available:

- Number and name of the groups in which the guidelines/recommendations were grouped
- Title and description of each guideline
- Source of information of guidelines: if the presented guidelines were obtained as a result of their own research or if they were the result or the compendium of previous publications
- Guidelines target population (autistic users, cognitive impaired users, or other)

3.1.1.5 Stage 5: Collating, summarising and reporting the results

In a scoping review the aim is to present an overview of all reviewed material without attempting to assess the quality of evidence and consequently it cannot determine whether particular studies provide robust findings (Arksey & O'Malley, 2005). So, attention was given to numerical analysis of guidelines, nature of grouping and source of information.

With the aim of collating and summarising results, the strategy adopted for grouping the guidelines was to frame them into the user experience elements when developing a website as prescribed by Garrett (2002), which divide a website development project into five user experience elements: strategy, scope, structure, skeleton and surface, as shown in Figure 3.3. From bottom to top, the elements are presented as dependent layers to the most abstract to the most concrete elements. On the highest level, the most concrete elements are listed and involve finer levels of details. Each layer is dependent on the definitions and decisions made in the layers below it.

In a practical way, the layers should be viewed as steps as when building a house, one must have the foundations and walls established before starting the painting and decorating process. The same applies when constructing a website: starting with the “strategy” and definition of the “scope”, then building the “structure” and navigation, thinking about the location and distribution of all elements named as the "skeleton", and finally, considering the "surface" design to see how the visual interfaces are presented to the users.

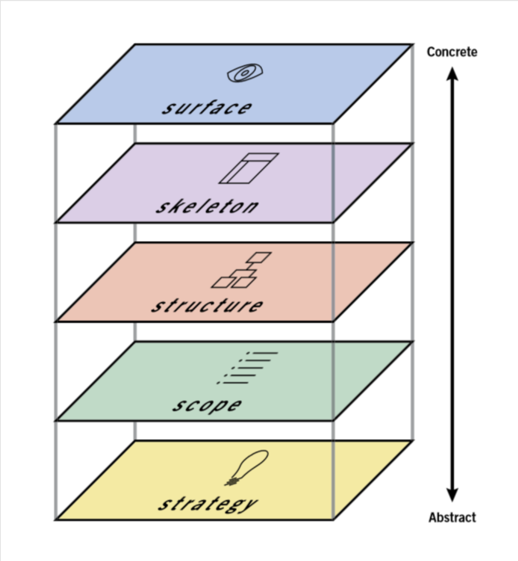


Figure 3.3 The Elements of User experience by Jesse James Garret (Garrett, 2002)

Each extracted guideline from each study was initially allocated to one of the five website development elements taking into account the element definition given by Garret (Garrett, 2002). This grouping method helped to identify the areas where most recommendations were focused and which other aspects of the web design process had fewer guidelines, and as a consequence, less documentation. As a result of the above, several issues and gaps in the literature about web accessibility for autistic users were identified.

3.1.1.6 Stage 6: Consultation exercise

The consultation exercise is optional in the adopted framework of the scoping review (Arksey & O'Malley, 2005). However, it has shown to confer multiple benefits (Jivraj, Sacrey, Newton, Nicholas, & Zwaigenbaum, 2014; Lilja & Bellon, 2008). Therefore, a focus group session was conducted with several autistic participants and members of the community that work with autistic individuals or have a family member on the autism spectrum. The aim of the focus group was to gather their feedback about the use, interpretation and preferences of different user interface elements, such as web-forms, menus, fonts, size and spacing, and general navigation and representation of element into a webpage. Some of the web design guidelines found during the scoping review were also analysed during the focus group and the participants complemented them with their own experiences. The complete details of the method, results and discussion of this focus group are presented in Section 3.2 of this thesis.

3.1.2 Results

The process of the scoping review is presented as a flowchart (Figure 3.4) and shows the method of data selection in accordance with the eligibility criteria.

The various mechanisms for identifying articles during the scoping review exercise generated a total of 473 references. Scopus and ProQuest databases generated records with no authors (n=60) corresponding to Conference proceedings summaries or Journal/Books/Meetings notes, so they were excluded from the study. Duplicate citations were removed manually (total of n=95), subsequent title and abstract relevance screening were conducted and non-relevant records (n=224) were excluded. Later, full-text articles (n=94) were assessed and additional records (n=85) were excluded. Finally, nine articles were included in the final report.

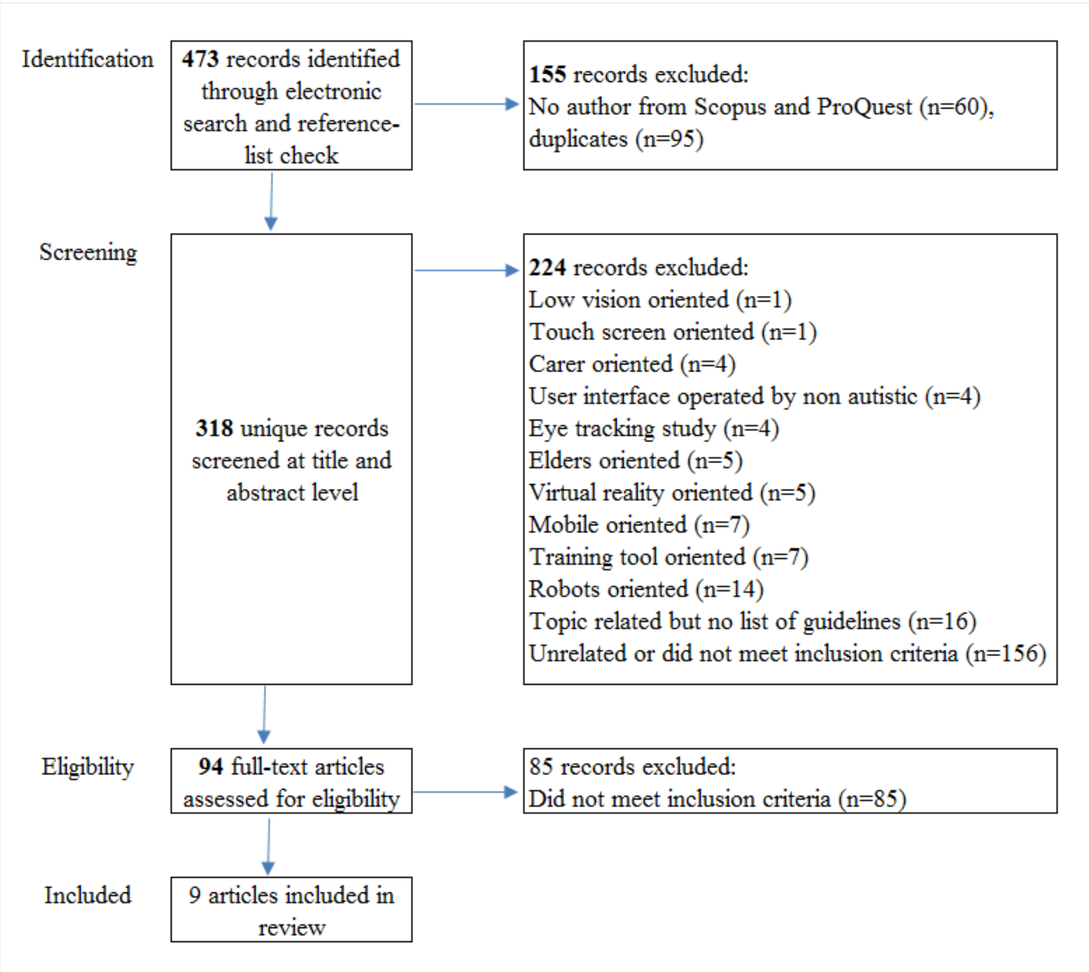


Figure 3.4 Scoping review process

From the final nine articles included in the review, one corresponded to a standard (W3C, 2019d), three corresponded to studies that had published web design guidelines as a result of aggrupation from previously published studies, and the last five articles corresponded to studies that had web design guidelines as compilations of previously published studies and the authors complemented these web design guidelines with their own research. The nine articles are presented in Table 3.3.

Table 3.3 Final articles included from the scoping review

Type of study or publication	Number of articles	Articles
Standard	1	(W3C, 2019d)
Compilation of published guidelines	3	(Britto & Pizzolato, 2016), (Dattolo & Luccio, 2017), (Friedman & Nelson Bryen, 2007)
Compilation of published guidelines complemented with own research	5	(Darejeh & Singh, 2013), (Harrold, Tan, & Rosser, 2012), (A. Hussain, Abdullah, Husni, & Mkpojiogu, 2016), (Pavlov, 2014), (Sitdhisanguan, Chotikakamthorn, Dechaboon, & Out, 2012)

The information collected in each article included: author(s) and year of publication, guidelines grouping technique, number of guidelines, sources of information (own research or compendium of others), and target population (autistic users, cognitive impaired users, or others). Consolidated information is presented in Table 3.4, shortened to Author/Study.

In total, 147 web design guidelines and recommendations related to web interface design for autistic users were found. 13 web guidelines corresponded to the web Standard “Web Content Accessibility Guidelines “ (WCAG) (W3C, 2019d) and the remaining 134 corresponded to web design guidelines and recommendations extracted from the remaining eight articles.

Detailed information about the 13 guidelines extracted from the web standard WCAG are presented in section 3.1.2.1, and the remaining 134 web design guidelines and recommendations are presented in section 3.1.2.2.

Table 3.4 Consolidation of standard and works related to web design guidelines.

Author(s) and year of publication	Number/name of groups in which guidelines/recommendations were grouped	Number of guidelines	Sources of information	Target population	Notes
Britto & Pizzolato (2016)	**10:** visual and textual vocabulary, customisation, engagement, redundant representation multimedia, feedback, affordance, navigability, system status and interaction with touch screen.	28	Synthesised 107 guidelines found in 17 international recommendations, commercial or academic software and peer-reviewed papers.	Autistic users	Visual and text vocabulary requirements are the most frequent guidelines among the included guidelines and recommendations.
Darejeh & Singh (2013)	*Not grouped*	5	Synthesised from previous work by Fryia et al. (2009), Grynszpan et al. (2008), and adapted based on own analysis according to the similarities between the user interface needs of users with less computer literacy.	Users with less computer literacy, including autistic users	This study presented two guidelines for cognitive impaired users and seven principles for designing user interfaces for users with less computer literacy, including autistic users.
Dattolo & Luccio (2017)	**4:** graphical layout, structure and navigation, user and language	18	List of guidelines found in the current literature and standards.	Autistic users	All tested apps lacked adaptability towards users.
Friedman & Nelson (2007)	*Not grouped*	22	Grouped 187 web design recommendations extracted from twenty publications into 22 final recommendations.	Users with cognitive disabilities, including autistic users	The top design recommendations covered elements of text size and shape, consistency of navigation and page design, use of icons, pictures, text-writing style, margins, hyperlinks, line spacing and screen-layout.

Author(s) and year of publication	Number/name of groups in which guidelines/recommendations were grouped	Number of guidelines	Sources of information	Target population	Notes
Harrold N., Tan C.T., Rosser D. (2012)	*Not grouped*	9	Their own study towards an Expression Recognition Autism Game.	Autistic users	The guidelines are related to: colours, feedback, images, guidance, text, sound, anxiety, hardware and repetition.
Hussain et al (2016)	**3:** form, content, behaviour	15	Design principles based on interaction design.	Autistic users	Guidelines towards improving “edutainment” apps.
Pavlov (2014)	**4:** presentation, navigation and panel loading, interaction and personalisation	30	Studies related to reading-comprehension difficulties for autistic individuals and from feedback of users and clinical professionals.	Autistic users	Guidelines implemented into a product (Open Book)
Sitdhisanguan, K., et al. (2012)	*Not grouped*	5	Learned lessons during the design and use of computer-based training systems for autistic children with high support needs	Autistic users	Some guidelines are specific to Tangible User Interfaces design (Tangible object size, tabletop size), while others are for general interfaces and Computer-based training design for children with autism. Only five guidelines related to web interfaces were included.
WCAG (2018)	**4:** perceivable, operable, understandable and robust.	13	Published by World Wide Web Consortium W3C.	All users	13 guidelines composed by 78 success criteria.

In order to collate and summarise the web design guidelines, each guideline was categorised as belonging to one of the previously described five elements by Garrett (Garrett, 2002) (strategy, scope, structure, skeleton and surface). Each guideline was assigned to one element as presented in Table 3.5. As a result, 11 web guidelines were assigned to the strategy element, 50 to the scope element, 43 to the structure element, 19 to the skeleton element, and 24 to the surface element.

When a given guideline corresponded to multiple elements, it was allocated to one element only. In general, it was allocated first to the element that was most relevant if the author provided an example, or if it did not have an example, it was allocated to the most abstract level. For example: Pavlov's guideline 2.6: "Use visual indicators for time-consuming actions" (Pavlov, 2014), could be allocated to the strategy element, because it is referring to the user's need of requiring more time to process the information on the screen, or to the skeleton element, because it recommends having a visual demonstration to obtain the user's attention. It was located as a strategy guideline given that it is a very important guideline for the wellbeing of the autistic users that it should be included since the very beginning in the specification of any new web project and it should be reinforced with visual elements on the webpage where time limits apply.

The complete list of web design guidelines and recommendations assigned to each web development element sorted by Author/Study is presented in Appendix B.

Table 3.5 Web design guidelines found during the scoping review assigned to the five web development elements

Author/Study	Strategy	Scope	Structure	Skeleton	Surface	Grand Total
Britto and Pizzolato, 2016	3	12	7	4	2	**28**
Darejeh and Singh, 2013		3	2	2		**7**
Dattolo and Luccio, 2017	1	9	6	2		**18**
Friedman and Nelson, 2007		8	7	2	5	**22**
Harrold, N., C.T. Tan, and D. Rosser, 2012	2	2	4		1	**9**
Hussain, A., et al., 2016		7	4	3	1	**15**
Pavlov, 2014	1	3	7	6	13	**30**
Sitdhisanguan, K., et al., 2012	1	1	2		1	**5**
WCAG (W3C), 2018	3	5	4		1	**13**
Grand Total	**11**	**50**	**43**	**19**	**24**	**147**

3.1.2.1 Web design standard guidelines

The analysis of the scoping review started with the analysis of the web standard "Web Content Accessibility Guidelines" (WCAG) which are documented by the International Organization for Standardization (ISO) and by the World Wide Web Consortium (W3C). The WCAG are a set of recommendations for making web content more accessible for all, and predominantly for people with disabilities (W3C, 2019d). They support making the Web accessible, independent of hardware, software, language, culture, location, or users with physical or mental ability (W3C, 2019d).

The latest version WCAG 2.1 has 13 guidelines organised under four principles: perceivable, operable, understandable and robust (W3C, 2019d). Details of these guidelines are presented in Table 3.6. For each guideline, there are testable success criteria, which are at three priority levels: A, AA and AAA. A being the basic and minimal expected level of accessibility, followed by level AA equating to a higher level of accessibility and level AAA equating to the highest level of accessibility (W3C, 2018b). There are in total 78 success criteria in WCAG 2.1, each with a different accessibility level (i.e., A, AA, or AAA) as presented in Table 3.7. All success criteria must comply within the same accessibility level to claim WCAG compliance at that level, i.e., a website can only claim it is WCAG 2.1 compliant at level AA if all success criteria for level AA are accomplished. There are exceptions of compliance in cases of third party licence/implementation issues (W3C, 2018b).

Table 3.6 WCAG 2.1 Web Content Accessibility Guidelines (W3C, 2019d)

Principle	Principle description		Guideline
1 Perceivable	Information and user interface components must be presentable to users in ways they can perceive.	1.1	Text Alternatives: Provide text alternatives for any non-text content so that it can be changed into other forms people need, such as large print, braille, speech, symbols or simpler language.
		1.2	Time-based Media: Provide alternatives for time-based media.
		1.3	Adaptable: Create content that can be presented in different ways (for example simpler layout) without losing information or structure.
		1.4	Distinguishable: Make it easier for users to see and hear content including separating foreground from background.
2 Operable	User interface components and navigation must be operable.	2.1	Keyboard Accessible: Make all functionality available from a keyboard.
		2.2	Enough Time: Provide users enough time to read and use content.
		2.3	Seizures and Physical Reactions: Do not design content in a way that is known to cause seizures or physical reactions.
		2.4	Navigable: Provide ways to help users navigate, find content and determine where they are.
		2.5	Input Modalities: Make it easier for users to operate functionality through various inputs beyond keyboard.
3 Understandable	Information and the operation of user interface must be understandable.	3.1	Readable: Make text content readable and understandable.
		3.2	Predictable: Make Web pages appear and operate in predictable ways.
		3.3	Input assistance: Help users avoid and correct mistakes.
4 Robust	Content must be robust enough that it can be interpreted by a wide variety of user agents, including assistive technologies.	4.1	Compatible: Maximise compatibility with current and future user agents, including assistive technologies.

Table 3.7 Success criteria and accessibility level in the WCAG Standard version 2.1 (W3C, 2019d)

Principle	Guideline	Success Criteria		Accessibility level
1 Perceivable	1.1 Text Alternatives	1.1.1	Non-text Content	A
	1.2 Time-based Media	1.2.1	Audio-only and Video-only (Pre-recorded)	A
		1.2.2	Captions (Pre-recorded)	A
		1.2.3	Audio Description or Full Text Alternative	A
		1.2.4	Captions (Live)	AA
		1.2.5	Audio Description	AA
		1.2.6	Sign Language	AAA
		1.2.7	Extended Audio Description	AAA
		1.2.8	Media Alternative	AAA
		1.2.9	Audio-only (Live)	AAA
	1.3 Adaptable	1.3.1	Info and Relationships	A
		1.3.2	Meaningful Sequence	A
		1.3.3	Sensory Characteristics	A
		1.3.4	Orientation	AA
		1.3.5	Identify Input Purpose	AA
		1.3.6	Identify Purpose	AAA
	1.4 Distinguishable	1.4.1	Use of Colour	A
		1.4.2	Audio Control	A
		1.4.3	Contrast (Minimum)	AA
		1.4.4	Resize text	AA
		1.4.5	Images of Text	AA
		1.4.6	Contrast (Enhanced)	AAA
		1.4.7	Low or no Background Audio	AAA
		1.4.8	Visual Presentation	AAA
		1.4.9	Images of Text (No Exception)	AAA
		1.4.10	Reflow	AA
		1.4.11	Non-Text Contrast	AA
		1.4.12	Text Spacing	AA
		1.4.13	Content on Hover or Focus	AA

Principle	Guideline	Success Criteria		Accessibility level
2 Operable	2.1 Keyboard Accessible	2.1.1	Keyboard	A
		2.1.2	No Keyboard Trap	A
		2.1.3	Keyboard (No Exception)	AAA
		2.1.4	Character Key Shortcuts	A
	2.2 Enough Time	2.2.1	Timing Adjustable	A
		2.2.2	Pause, Stop, Hide	A
		2.2.3	No Timing	AAA
		2.2.4	Interruptions	AAA
		2.2.5	Re-authenticating	AAA
		2.2.6	Timeouts	AAA
	2.3 Seizures and Physical Reactions	2.3.1	Three Flashes or Below Threshold	A
		2.3.2	Three Flashes	AAA
		2.3.3	Animation from Interactions	AAA
	2.4 Navigable	2.4.1	Bypass Blocks	A
		2.4.2	Page Titled	A
		2.4.3	Focus Order	A
		2.4.4	Link Purpose (In Context)	A
		2.4.5	Multiple Ways	AA
		2.4.6	Headings and Labels	AA
		2.4.7	Focus Visible	AA
		2.4.8	Location	AAA
		2.4.9	Link Purpose (Link Only)	AAA
		2.4.10	Section Headings	AAA
	2.5 Input Modalities	2.5.1	Pointer Gestures	A
		2.5.2	Pointer Cancellation	A
		2.5.3	Label in Name	A
		2.5.4	Motion Actuation	A
		2.5.5	Target Size	AAA
		2.5.6	Concurrent Input Mechanisms	AAA
3 Understandable	3.1 Readable	3.1.1	Language of Page	A
		3.1.2	Language of Parts	AA
		3.1.3	Unusual Words	AAA
		3.1.4	Abbreviations	AAA
		3.1.5	Reading Level	AAA
		3.1.6	Pronunciation	AAA

Principle	Guideline	Success Criteria		Accessibility level
	3.2 Predictable	3.2.1	On Focus	A
		3.2.2	On Input	A
		3.2.3	Consistent Navigation	AA
		3.2.4	Consistent Identification	AA
		3.2.5	Change on Request	AAA
	3.3 Input assistance	3.3.1	Error Identification	A
		3.3.2	Labels or Instructions	A
		3.3.3	Error Suggestion	AA
		3.3.4	Error Prevention (Legal, Financial, Data)	AA
		3.3.5	Help	AAA
		3.3.6	Error Prevention (All)	AAA
4 Robust	4.1 Compatible	4.1.1	Parsing	A
		4.1.2	Name, Role, Value	A
		4.1.3	Status Messages	AA

3.1.2.2 Extracted web interface design guidelines

The 136 web design guidelines and recommendations found during the scoping review are presented below. The approach is to present the web design guidelines by author-name and year-of-study and to explain how the author(s) grouped them.

Britto and Pizzolato, 2016

Britto and Pizzolato (2016) initially identified a total of 107 guidelines based on 17 international recommendations, commercial or academic software and peer-reviewed papers published between 2005 and 2015. However, Pavlov’s (2014) web design guidelines were not included in the list of guidelines presented by Britto and Pizzolato. As presented in Table 3.8, the authors grouped the guidelines into 10 categories using the affinity diagram technique, resulting in the publication of 28 guidelines.

Table 3.8 Web design guidelines (Britto & Pizzolato, 2016).

Category		Guideline Title	
1	Visual and Textual Vocabulary	1.1	Colours should not be the only way to deliver content and the contrast between background and objects in foreground must be appropriate to distinguish items and distinct content or relate similar information
		1.2	Use a simple visual and textual language, avoid jargons, spelling errors, metaphors, abbreviations and acronyms, using terms, expressions, names and symbols familiar to users' context
		1.3	Be succinct, avoid writing long paragraphs and use mark-ups that facilitate the reading flow such as lists and heading titles
		1.4	Icons, images and label of menus and actions should be compatible to real world, representing concrete actions and everyday life activities in order to be easily recognised
2	Customisation	2.1	Allow colour, text size and font customisation for interface elements
		2.2	Provide options to customise information visualisation with images, sound and text according to individual user's preferences
		2.3	Provide options to customise the amount of element in the interface, their arrangement and enable features personalisation
		2.4	Enable a reading or printing mode for activities involving reading and concentration
3	Engagement	3.1	Avoid using elements that distract or interfere in focus and attention. In case you use it, provide options to suppress those elements on screen.
		3.2	Design simple interfaces, with few elements and which present only the features and content need for the current task to be performed by the user
		3.3	Use blank spaces between Web page elements to separate different contents or focus the user attention on a specific content
		3.4	Provide clear instructions and orientation about tasks to ease the user understanding of the content and the content language, in order to stimulate, motivate and engage the user
4	Redundant Representation	4.1	The Website or Web application must not rely only in text to present content. Provide alternative representations through image, audio or video and ensure that they will be close to the corresponding text
		4.2	Symbols, pictograms and icons should present a textual equivalent near to facilitate symbol understanding and contribute to enrich user's vocabulary
		4.3	Provide audio instructions and subtitles for texts, but ensure that this is not the only alternate content representation

Category		Guideline Title	
5	Multimedia	5.1	Provide information in multiple representation, such as text, video, audio and image for better content and vocabulary understand, also helping users focus on content
		5.2	Allow images magnification for better visualisation and ensure they continue to be understandable when enlarged
		5.3	Avoid the use of disturbing and explosive sounds, like sirens or fireworks
6	Feedback	6.1	Provide feedback, confirm correct actions or alerting about potential mistakes, and use audio, text and images to represent the message, avoiding icons with emotions or facial expressions
7	Affordance	7.1	Similar elements and interaction must produce similar, consistent and predictable results
		7.2	Use bigger icons, buttons and form controls that provide appropriate click/tap area and ensure that the elements look clickable
		7.3	Provide immediate instructions and feedback over a interaction restriction with the system or a certain interface element
8	Navigability	8.1	Provide a simplified and consistent navigation between pages, use location and progress indicators and present global navigation buttons (Exit, Back to home page, help) on every page
		8.2	Avoid automatic page redirects or expiration time for tasks. The user should control the navigation and time to perform a task
9	System status	9.1	Present appropriate instructions to interact with interface elements, provide clear messages about errors and provide mechanisms to solve the errors
		9.2	Allow critical actions to be reverted, cancelled, undone or confirmed
		9.3	In interactive lessons and educational activities, it is recommended allowing up to five attempts before showing the correct answer
10	Interaction with touch screen	10.1	Touch screen interactions should have the appropriate sensibility and prevent errors in selections and accidental touch in interface elements

Darejeh and Singh, 2013

Darejeh and Singh (2013) proposed seven principles for designing user interfaces for users with less computer literacy, including autistic users. The principles are presented below:

1. Eliminating features that could cause unnecessary stress and frustration, and reducing software complexity by reducing the number of features available at any given time
2. Designing an interface such that it does not need investigation for finding tools

3. Using larger components such as large buttons, combo boxes. Furthermore, using bigger icons and fonts for showing key functions of the software
4. Avoiding using computer terms and the names that are not familiar to all users for naming tools
5. Putting customisation ability for font, colour and size, especially for elders, children and people with visual impairments
6. Using enough descriptive texts, especially for helping elderly and blind people
7. Using appropriate graphical objects like avatar or icons for increasing software attraction, especially for children and also for attracting the attention of people with cognitive problems.

Dattolo and Luccio, 2017

Dattolo and Luccio (2017) proposed 18 guidelines, distributed into four categories (i.e., graphical layout, structure and navigation, user and language). They evaluated the guidelines against selected websites and mobile applications and found that none of them satisfied the guideline U3: "Make adaptive the interaction with users, considering their interaction history, their preferences, requests and needs." Details of these guidelines are presented in Table 3.9.

Table 3.9 Web design guidelines (Dattolo & Luccio, 2017).

Category	Guideline title
Graphical layout	G1 The general design and the structure should be simple, clear and predictable, secondary content that distracts the user should be avoided. The number of features available at any time instant should be limited.
	G2 The content should be predictable and should provide feedback.
	G3 Pictures should be copiously used together with redundant representation of information.
	G4 Pictures can be drawings, photographs, symbolic images, should be easy to understand, should not go in the background and should be in a sharp focus.
	G5 Background sounds, moving text, blinking images and horizontal scrolling should be avoided.
	G6 The text should go with pictures. It should be clear, simple and short (at most one sentence on a line); should be in a big font (14), in plain Sans-serif style (e.g., Verdana), in a mild colour. Headings and titles should be used.
	G7 The interface should be responsive.
Language	L1 The language should be simple and precise.
	L2 Acronyms and abbreviations, non-literal text and jargon should not be used.

Category	Guideline title
Structure and navigation	N1 Navigation should be consistent and similar in every page/section.
	N2 The website and every mobile application should have a simple and logical structure. Even the first time, the user should be able to easily navigate inside and should remember the navigational information even at successive visits or uses.
	N3 Add navigation information and navigation buttons at the top and the bottom of the page.
	N4 Efficiency and availability.
User	U1 Allow customisation.
	U2 Try to engage the user.
	U3 Make adaptive the interaction with users, considering their interaction history, their preferences, requests and needs.
	U4 Decompose the tasks into simple subtasks.
	U5 The number of errors should be limited.

Friedman and Nelson, 2007

Friedman and Nelson (2007) grouped 187 web design recommendations extracted from twenty publications. The recommendations were analysed and combined resulting in a final list of 86 individual web design guidelines. The top four recommendations were 1) Use pictures, graphics, icons and symbols along with text (75% agreement), 2) Use clear and simple text (70% agreement), 3) Use consistent navigation and design on every page (60% agreement) and 4) Use headings, titles and prompts (50% agreement). These are the 22 resulting guidelines:

1. Use pictures, icons and symbols along with text.
2. Use clear and simple text.
3. Consistent navigation and design on every page.
4. Use headings, titles and prompts.
5. Support screen readers. Use alternate text tags.
6. Use larger fonts, fonts in minimum 12pt or 14pt.
7. Uncluttered, simple screen layout.
8. Maintain white space: Use wide margins.
9. Website customisable, control of: type size, placement of navigation (right, left side) contrast, large print, sound.
10. Use exit, home, help, next page buttons on every page.
11. Use sans serif fonts, such as Arial, Verdana, Helvetica and Tahoma.
12. Navigation buttons clear, large and consistent.
13. Use numbered lists rather than bullets.

14. Support font enlargement for Web browsers.
15. Use colour for contrast.
16. Check reading level with automated tool.
17. Do not right justify text; use ragged edge right hand margins.
18. Use lower case, no ALL CAPS.
19. Provide voice captions (audio files) for text.
20. Provide audio/voice-overs where the words are read aloud.
21. Use navigation methods, i.e., "undo" or "back button" to help user recover when lost.
22. Give feedback on a user's actions (e.g. confirm correct choices, alert users to errors or possible errors).

Harrold, N., C.T. Tan and D. Rosser, 2012

Harrold, N., C.T. Tan and D. Rosser (Harrold et al., 2012) summarised nine guidelines for designing autism applications based on their own study towards an Expression recognition autism game. Their guidelines are presented in Table 3.10.

Table 3.10 Guidelines for designing autism applications (Harrold et al., 2012)

Guideline	Description
Colours	Distinct differences in hues and the brightness of colours should be evident so that the UI is easily distinguished from the game base.
Feedback	User feedback should be presented with the use of distinct colour and narrative guidance. Facial expressions should not be used as a means of communicating a correct or incorrect answer. A correct answer to a problem should be provided after some unsuccessful/incorrect attempts. The system should allow no more than five unsuccessful attempts before showing the answer.
Images	Using images to describe concepts eliminates the necessity to read. Using real photos instead of computer-generated images can in some cases be more effective when understanding facial expressions.
Guidance	A narrative voice can be used to draw the attention of a child back to the application if no response is received for a certain time period. Audio guidance can serve as a temporary substitute for a carer's instruction.
Text	The application should not rely on a child's ability to read as this can exclude those unable to read.
Sound	Pleasant sounds and calming or happy music are preferable. Sounds should not be too loud or intrusive.
Anxiety	All efforts should be made to create an application that does not induce anxiety in a child or make failure a fearful prospect. Children with ASDs should not be punished for incorrect answers as this can cause a fear of failure and limit emotional development.
Hardware	Using a touch device is preferable as it eliminates the necessity for the hand-eye coordination skills a mouse and keyboard setup requires.
Repetition	Repetitive tasks or actions may aid in the development and reinforcement of positive behaviours.

Hussain, A., et al., 2016

A. Hussain et al. (2016) published 15 guidelines based on the interaction design principles of form, content and behaviour. They presented the interactive design for edutainment systems and enhancing the communication skills of children with autism. Their principles are presented in Table 3.11.

Table 3.11 Design principles by A. Hussain et al. (2016)

Dimension	Design Principles	Suitable Design
Form	1 User Interface	Designed to be simple, without much visual stimuli, in order to maximise the chance of concentration, comprehension and learning of the children
	2 Number of pictures	In each page, the number of pictures should be within the acceptable limit
	3 Screen size	The screen size of the images should be made very large to make it easier for the users to see the items and to enable them to correctly press/tap each item on the screen without accidentally hitting another icon/button
	4 Icon	The icon of the home page should be easily distinguished
	5 Colour	An alternative colour should be used since, often, the black colour is found to be repulsive
Content	6 Guide the user through the app	To guide the user through the app, a caregiver should be made available
	7 Admin section	The admin section should be protected with a password
	8 Picture Exchange Communication System	Communication should be based on the Picture Exchange communication System (PECS), which uses images specifically developed for children with communication impairments
	9 Audio	The audio aspects should correspond with the images. It should also be user-friendly and in an appropriate number
	10 Language	The language used in this app should be given consideration
	11 Upload photo	There should be an option for uploading photographs.
	12 Pronunciation	There should be a function enabling the pronunciation of the completely formulated sentence

Dimension	Design Principles	Suitable Design
Behaviour	13 Evaluating parameter	There should be some evaluating parameter in the App to measure the child's growth
	14 Image life	Having images identical to real life objects facilitates easier recognition and allows children to learn more efficiently and effectively
	15 Navigation	There should be simple navigation buttons

Pavlov, 2014

Pavlov (2014) presented 30 recommendations in four categories: presentation, navigation and panel loading, interaction and personalisation. The recommendations were based on the WCAG standard, the principles published by the United Kingdom Department of Health for preparation of documents for people with learning disabilities and the "Easy to read guidelines" project (Freyhoff, 1998) (See Table 3.12). Implementation of these recommendations was adopted in the interface of the Open Book product for which positive feedback was obtained by autistic users (Pavlov, 2014).

Table 3.12 Web design guidelines (Pavlov, 2014)

Category	Guidelines
Presentation	Do: • Use contrast between font and background. • Use soft, mild colours. • Make sure text box is clearly separated from the rest. • Present text in a single column. • Use simple graphics. • Use clear, sans-serif fonts. Do not: • Do not use bright colours. • Do not user background images. • Do not overlap transparent images and text. • Do not use pop-up elements and distractions. • No element should stand out too much. • Do not have horizontal scrolling.

Category	Guidelines
Navigation and page loading	Do: • Strive for simple, clear navigation. • Indicate on each page clearly where the user is. • Support navigation with mouse or keyboard. • Allow the use of browser's buttons. • Pages should load fast. • Use visual indicators for time-consuming actions. • Have a Help button. Do not: • Do not use complex menus.
Interaction	Do: • Design for simplicity and few elements on screen. • Try to have one toolbar. • Use clear, large buttons with both icons and text. • Give short instructions of use at every step. Do not: • Avoid cluttered interface. • Do not use many-colored icons. • Avoid buttons with icons only, except for the most popular actions. For example, "back".
Personalisation	Allow personalisation of: • Font type and size. • Line-spacing. • Themes for text background and foreground colours.

Sitdhisanguan, K., et al., 2012

Sitdhisanguan et al. (2012) studied tangible user interfaces and computer-based training systems for autistic children with high supporting needs. Based on lessons learned in the design of such interfaces, they presented seven guidelines for a user interface design for autistic users. As only five of them applied to web interfaces, they are the ones included in the scoping review as presented in Table 3.13.

Table 3.13 Guidelines for general user interface design for autistic users (Sitdhisanguan et al., 2012)

Guideline	Description
1 Learning stimulation	A stimulation, i.e., narrative voice, should be applied to bring back attention if the system do not receive response from the user for a certain time period.
2 Use of sound	Children with autism may be excessively sensitive to certain sounds. Thus, it is suggested that disturbing and explosive sounds such as those of a buzzer or exploding fireworks should be avoided.
3 Incorrect-response feedback	Children with autism have a limited understanding of human emotions and behaviour, as a result, they may not be able to understand correctly the meaning that such feedback attempts to communicate.
4 Giving a correct answer	Repetitive unsuccessful/incorrect attempts should be controlled as a maximum of five before to present a correct answer to avoid frustration.
5 Choice of foreground/background colour	Most children with autism lack figure-ground perception. To avoid possible confusion, the colour of the background must be different enough to that of the foreground object.

3.1.3 Discussion

The scoping review found in total 147 web design guidelines and recommendations extracted from one standard (WCAG) and nine studies related to web interface design for autistic users. It is evident that web developers and web content creators could have difficulties understanding the needs of autistic users when they navigate desktop websites, given that there is no centralised information to guide them to make accessible websites for autistic users. There was a need to collate these web guidelines and recommendations to facilitate their understanding and applicability in the web development process.

Using the five website development elements described by Garrett (2002), provided a useful framework in which guidelines could be collated and synthesised. Such a framework can provide website developers with an overview of key aspects for each development element. Using this framework also helped clarify that most guidelines to date applied to the element constituting the planning of web development. This indicates the importance of understanding the needs of your user early in the website development process. The use of the five development elements framework may also help web developers to visualise how incorporating guidelines throughout the development process facilitates the implementation, resulting in optimised web navigation for autistic users.

With the scoping review resulting in 147 web design guidelines, it was deemed important to consult with autistic users and their close community through a focus group, to further understand how web design is perceived by them and to validate the web design guidelines found during the scoping review.

3.2 Focus group

3.2.1 Method

A focus group generates valuable research data by facilitating discussions and interaction between group members that have met to focus around a particular topic (Onwuegbuzie, Dickinson, Leech, & Zoran, 2009). Face-to-face discussions enable more spontaneous responses and can provide a sense of belonging, helping the participants to feel safe to share information (L. P. Wong, 2008). This research method is particularly good when the aim is to elicit people's understanding, opinions and views, and to explore how these can be elaborated in a social context (Wilkinson, 1998) which was the objective of this focus group. The method used to conduct the focus group followed the procedure presented by L. P. Wong (2008) which includes the following: planning the research questions, design the discussion guide, planning for and executing the recruitment of participants, setting the venue, planning the data collection and analysis, and finalising with the reporting of findings.

Research questions

This focus group aimed to further the understanding of how web design is perceived by autistic users and their close community, and to discuss and validate some of the web design guidelines and recommendations found during the scoping review.

Discussion guide

The focus group started with the moderator explaining the objective of the focus group and the concepts of user interface, web design and web accessibility. This introduction was followed by the presentation of the user interface elements and the proposed recommendation of how to use them to facilitate a good web user experience for autistic users presented below. All participants were invited to ask questions and give their opinions about the user interface elements during and after the presentation. Some questions guiding the discussion were: do you agree with the recommendation? Is there anything else that should be considered/would be more helpful for autistic users? All web design guidelines and recommendations that were discussed during the focus group are presented in Appendix C, below are some examples of the user interface elements discussed during the focus group.

User interface elements that were discussed in the focus group

- Focus text input: the focus in any text-field should be relevant to show that the user is located in that field. The use of a tick border using a different colour than the other buttons is recommended.
- Buttons, icons with text: it is recommended that buttons, icons and text be combined with colours where appropriate. For example, the Save, Delete, or Edit icons should have the corresponding label. Error icons are usually in colour red and icons expressing success are usually in colour green. Icons and alerts expressing a warning are usually on colour yellow.
- Dates in full format: for example, Tuesday, 2nd of May 2017 is always preferable instead of 02/05/17. Always prefer to format date fields with full text, and explain the meaning of the order in the fields given that different countries have different preferences. A date in United States is usually formatted as month/day/year versus in Australia where a date is formatted as day/month/year.
- Telephone number separated: phone numbers should be formatted to present the digitals as groups of three to four numbers according to the type of phone number. For example, mobile phones as (123)345 345, and international numbers as (+61)123 456 789.
- No animations or moving images. No gif: gif is a type of format that presents moving images or text should be avoided.
- No block or italic font: italics and bold fonts are harder to read so the recommendation is to use regular type fonts.
- No picture as background: images as background should be avoided as any text over an image is hard to read
- No horizontal scrolling: the recommendation is to avoid horizontal scrolling and it is best to distribute the information in a vertical way.
- No time limit: any form or information in a website that requires a time limit should be avoided.
- No hyphenated words (Figure 3.5): keep words together at the end of each line.

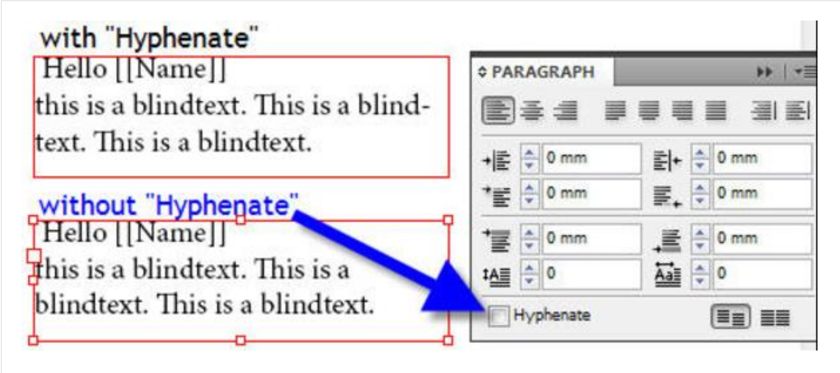


Figure 3.5 **Example of words hyphenated across a line break**

- Breadcrumb: the use of breadcrumbs is highly recommended to facilitate navigation on every web page. A breadcrumb is a visual and clickable link to the webpages, and it presents where the user is at in a website. For example, if a website has 4 levels of menus, and if the user is currently located at level 4, the breadcrumb will show: Home (level 1), Menu 1 (Level 2), Menu 2 (Level 3), and Menu 3 (Level 4).
- No alignment on right: text should be always aligned on the left-hand side, as centre, block or right are harder to read.
- Text alternatives for non-text content: text alternatives should be used for images that are not decorative (Figure 3.6).

Figure 3.6 **Example of a logo with alternative text**

- Colour contrast: High contrast between text and background: there are combinations between colour font and background that facilitate readability. Some combinations are totally inaccessible (Figure 3.7).

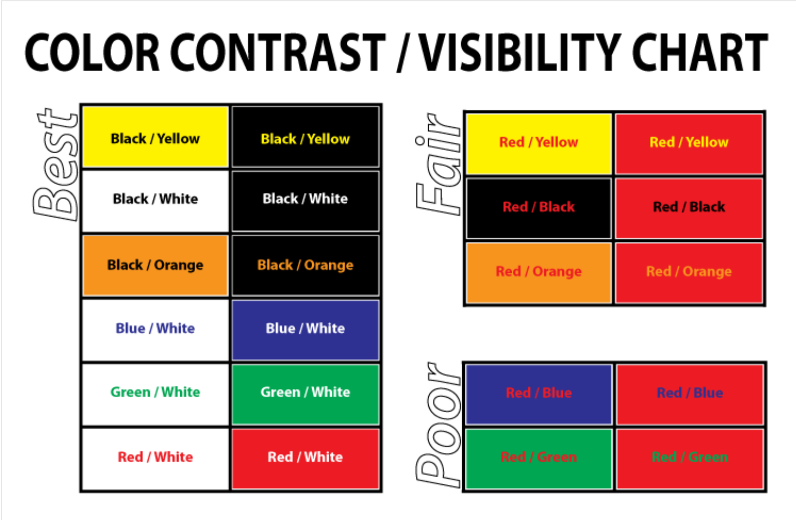


Figure 3.7 Example of different colour contrast options

- Help buttons, visual tips: when users are filling web forms, the alerts and visual messages should be easy to understand, and they should have an icon and text to indicate the meaning of the alert.

Participant's recruitment and group composition

The invitation to participate in this focus group was sent by email to several autistic adults and community members. The invitation included an attached document explaining the objective of the focus group and the user interface element that would be analysed during the meeting (Appendix C). In total, eight people accepted and attended the meeting. The group comprised:

- Two autistic adults;
- Two carers/parents of autistic individuals;
- Three disability senior consultants with experience working with autistic people;
- One former special education teacher and now senior research fellow with more than 20 years' experience working with autistic individuals and research in autism.

Setting the venue

The meeting was conducted at Curtin University, Perth, Western Australia. All participants were informed that their contributions would remain confidential and that the data would only be accessible by the research team. All participants agreed to the meeting being audio-recorded. The duration of the meeting was scheduled for two hours.

Procedures and data collection

The focus group began with a presentation of user interface elements and the web design guidelines from the researcher. The group then discussed the recommendations and clarified description/concepts. General notes were taken and discussions and feedback from the participants were handwritten and audio recorded.

3.2.2 Results

All participants agreed that web design guidelines are needed to facilitate the navigation and understanding of desktop websites for autistic users. Each user interface element was presented and recommendations were discussed and mostly validated after being complemented by additional feedback. The key findings from the focus group members were:

- The user interface should be minimalist and clear, with no decorative and distracting elements.
- The language should be simple and direct.
- If the user is allowed to change the font, the different font options should be demonstrated showing the font itself keeping the same size as how it would be presented in the website.
- When asking for colour contrast, the label should read “Font colour” on “background colour”. E.g. Black on white.
- When there is an error message during filling-in forms, the focus and emphasis should direct the users’ attention on the field presenting the error. Sometimes there are websites showing an alert in the top or bottom of the page but there is no clear indication of where the missing or incorrect field is.

As all web design guidelines found in the scoping review were currently allocated to one web development element (strategy, scope, structure, skeleton or surface), the recommendations and feedback obtained in the focus group were analysed and it was verified that they were included in the group of 147 web design guidelines. It was notable that web design guidelines corresponding to the surface element are more predominant and are more relevant for autistic users.

3.2.3 Discussion

The focus group provided autistic users and members of the community with an opportunity to share their opinions and feedback about several web user interface elements and web design guidelines found in the scoping review.

One of the challenges of conducting the focus group was that the terminology used to describe elements on a web user interface are not familiar to all participants. Despite the fact that the participants were provided with the visual examples of the user interface elements to be discussed, the terminology used needed to be explained and the elements' implication, design, and presentation in a website clarified before the participants could provide their feedback.

The importance of simple navigation and the absence of distracting elements in websites were reinforced by all participants on multiple occasions. Most participants agreed that the most annoying elements into a website are blinking and moving graphics. This indicated that all the web design guidelines referring to presentation and moving elements should be considered as critical in any website.

3.3 Affinity diagram

3.3.1 Method

The affinity diagram method, know as well as "KJ method" (named after the creator, Jiro Kawakita), is used to organise large and heterogeneous amount of data into groups based on natural relations (Scupin, 1997). The aim of the method is to merge a large number of ideas to provide a more useful overview of key aspects, allowing a new pattern to emerge. The recorded data is evaluated from different perspectives before being classified. In the case of this research, the aim was to form meaningful groups from all web design guidelines found during the scoping review and the feedback received during the focus group.

During the scoping review 147 web design guidelines were found and as a first filtering, each of them was initially allocated to one of the website development elements described by Garrett (strategy, scope, structure, skeleton and, surface). In this process, 11 web guidelines were assigned to the strategy element, 50 to the scope element, 43 to the structure element, 19 to the skeleton element and 24 to the surface element. Continuing using the affinity diagram technique, where similar items/description are grouped based on natural relationships (McConnell, 1992), more similarities were identified between guidelines facilitating the generation of a smaller list of guidelines. For example, all web guidelines corresponding to colour contrast and visual elements were allocated to the surface element.

Thereby, all web interface design guidelines and recommendations obtained from the scoping review, the reference group, and the affinity diagram constitute the results presented in this chapter as the web design framework for autistic users.

3.3.2 Results

After several rounds of analysis and grouping by similarities as guided by the affinity diagram method, the web design framework for autistic users has a compendium of 13 web interface design guidelines as a result of the scrutiny and synthesis of the data found during the scoping review and the focus group, and the grouping applied with the affinity diagram. The five elements of developing a website provided a conceptual framework to list the 13 web interface design guidelines that constituted the proposed web design framework for autistic users. The strategy element comprises two guidelines; the scope, structure and skeleton elements have three guidelines each, and the surface element has two guidelines. They are presented in Table 3.14.

Table 3.14 Web interface design guidelines for autistic users

Element	Web design guideline	
Strategy	1	Avoid the use of moving elements
	2	Provide enough time on general tasks
Scope	3	Allow customisations according to user preferences
	4	Provide multiple source of information
	5	Use simple language to facilitate readability
Structure	6	Include help and errors feedback
	7	Use literal and concrete actions language
	8	Provide simplicity and consistency during navigation
Skeleton	9	Design for simplicity and consistency to maximise focus and attention
	10	Use simple graphic elements
	11	Use enough spacing and size between the different user interface elements
Surface	12	Use a colour contrast that facilitates readability
	13	Avoid too many distracting elements and colours

The guidelines contained in this framework are intended to be used by people who design websites and user interfaces. Others who may be interested include people working on accessibility compliance, web testing and web usability. Firstly, each element for developing a website is explained, and later their correspondent web interface design guidelines are listed and explained with examples when needed. The proposed web interface design guidelines conclude with an explanation about the role of non-functional requirements into software engineering and the presentation of two non-functional guidelines for a good web user experience for autistic users.

3.3.2.1 Element 1 - Strategy

When developing a website, the strategy element includes the site objectives and user needs. Strategy incorporates not only the objectives of the people running the site, but also those of the users of the site (Garrett, 2002).

The site objectives define the website brand identity; they extend beyond the visual elements and encompass the conceptual associations or emotional reactions that the user will experience using the website (Garrett, 2002). User needs should be analysed following the principle of user-centred design which states that there is no proper design for all groups of users (Bergman & Johnson, 1995; Darejeh & Singh, 2013). Hence, since the focus of this thesis is on the autistic user, the following are the web interface design guidelines that apply to a website creation for this user group during the strategy element.

Guideline 1: Avoid the use of moving elements

Avoid the use of moving elements such as flashing text, blinking images, automatic dropping-down menus, carousels, lists or page sections.

This guideline has been included as part of the planning element of the design given that the majority of autistic users have a tendency to avoid any moving element and this condition affects all elements in the design process.

Examples of moving elements include, but are not limited to:

- Images with GIF extension: GIF files tend to move or blink constantly.
- Blinking texts or images: to draw people's attention blinking alerts are sometimes used on the sides of webpages, however the recommendation is to avoid them as they can cause seizures and physical negative reactions in many web users.
- Carousel in the home page: many websites have a carousel-style image in the home page presenting several different images constantly moving. The recommendation is to avoid this kind of user interface elements given that it requires time and exceptional focus to read the information at the required speed. If this element is used, the user

should be able to pause, stop and manually control the sequence. See Figure 3.8 as an example of a carousel in a webpage.

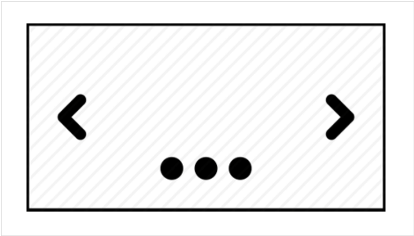


Figure 3.8 Example of carousel or slider screen in a website

Guideline 2: Provide enough time on general tasks

Time constraints to fill forms should be avoided and in case they are needed, they should have a visual indicator where the user can save and continue working without losing the information already filled in.

When possible, provide the functionality to frequently auto-save information inputted into forms. Use a question to check if the user is still working on the form, for example: Are you still there? And if the user selects the option “yes”, the timer should reset or extend. There are many ways to allow more time for users to complete tasks on a website. The recommendation is to always advise of the time limit, provide warnings if the expiration time is approaching and give the option to extend it.

3.3.2.2 Element 2 - Scope

The scope element during a website project includes setting the functional specifications and content requirements. The functional requirements are specific functionalities that the website should provide in terms of software requirements (Garrett, 2002). Content requirements can be explained in terms of the different versions of a product, i.e., desktop, tablet and mobile versions – depending on the hardware type a website can display different content. It is not the same to display a website on a laptop than on a tablet or a mobile phone. The different versions of a website should be analysed at this stage of the project; usually the version accessed on a mobile phone has less functionality than the desktop version (Dattolo & Luccio, 2017; Quezada et al., 2017).

The content requirements that should be analysed are the texts, the images, the video and the audio that is included into the website. Multimedia management is detailed in the guideline relevant to this feature (guideline 13). At this stage of the analysis, it is relevant to define the elements to be used without defining their implementation:

- Text: what text will be included on the website? The objective of this definition is to have an idea about the text that will be included on each page; there is no need to define specifics, only a general sense is required at this point of the analysis.
- Images: what images will be used on the website? It is important to define the size and alternative text of each image so visually impaired users using alternative technology can understand the relevant images that are used on the website.
- Video: is video going to be used on the website? As a general recommendation, the videos on a website should not exceed three minutes, and the user should always be able to stop and pause it.
- Audio: is audio going to be present on the website? Every audio segment must include a transcript, and the user should be able to pause and stop it.

It is important to define this information in order to plan for the space these elements require in a webpage. It is important as well to prioritise these requirements in case at a later stage there is no space in a given webpage to allocate all important information. Prioritising this early helps designers to plan where to start.

Guideline 3: Allow customisations according to user preferences

The user should be able to customise the majority of elements in the user interface, including font, colours and spacing.

To implement this guideline, the user should be able to see how the personalisation will look in a visual example. For instance, the website should present how personalised options will look with different fonts and different colour contrast selected by the user.

Fonts are classified according to their physical characteristics (calligraphy) into families, see Figure 3.9 for examples about calligraphy styles depending on the font family. It is demonstrated in this thesis (Chapter 5) that the preferred font by autistic users is the sans-serif font called Arial.

Generic family	Font family
Serif	Times New Roman Georgia
Sans-serif	Arial Verdana
Monospace	Courier New Lucida Console

Figure 3.9 Font types

Dyslexic users require a font with wider strokes and spacing to facilitate readability and understanding. Figure 3.10 shows a preferred font for dyslexic users.

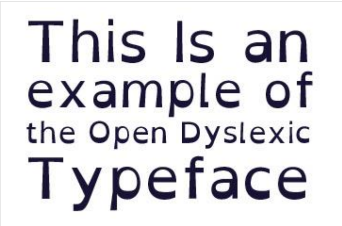


Figure 3.10 Dyslexic font

The user should be able to adjust the font size according to their visual skills, and if a website provides an option to adjust the size of the font this change should affect all elements and apply to all user interface elements including icons, titles and alerts. Figure 3.11 shows examples of fonts on different sizes.

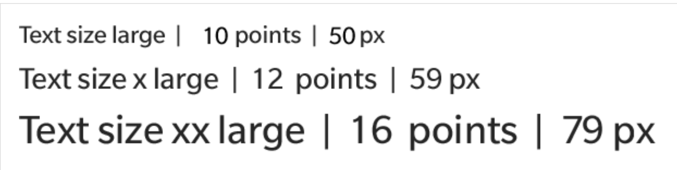


Figure 3.11 Example of fonts in different sizes

The font alignment should be on the left as presented in Figure 3.12. Speakers of English and other languages with a left-to-right script scan a page from left to right, and from top to bottom of the page (Weinschenk, 2011). The recommendation is to avoid block alignment because this reduces the readability of sentences.

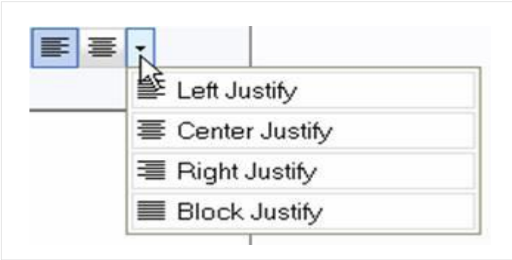


Figure 3.12 Font alignments

Guideline 4: Provide multiple sources of information

Information should be available in several modes allowing the user to process it in different modalities.

Multimedia should be presented in different ways, for instance video captions and audio transcript are useful for many users. A video should have captions and a transcript, and an audio-only piece should have a corresponding transcript.

Text alternatives are required for non-textual content that is not decorative. Some users may use screen readers to navigate content and require an explanation about image, tables and graphs. If the image or non-text content is decorative, there is no need to create text alternatives.

Guideline 5: Use simple language facilitating readability

Simple and clear language is required to facilitate readability and understanding (Al-Badi et al., 2012). This is one of the most important guidelines when designing websites for autistic users given that one common difficulty among them is language interpretation and complex sentences analysis (Brown & Elder, 2014). They can have a tendency to interpret speech literally rather than in reference to context (Grynszpan et al., 2008).

Readability tools provide a quick and easy way to test the readability of texts. An average text should suit a user with a reading age of a person in the first grade of high school. Any text requiring a higher level should be avoided or modified with simpler terminology.

There are several online tools to facilitate this evaluation, some recommended websites to analyse text-readability are:

- https://www.webfx.com/tools/read-able/
- http://www.readabilityformulas.com/free-readability-formula-tests.php
- https://www.online-utility.org/english/readability_test_and_improve.jsp

3.3.2.3 Element 3 - Structure

The structure layer of a website project defines the way the interaction will be done, and this is called the interaction design, which includes the behavioural patterns of users and how the system will accommodate and respond to that behaviour (Garrett, 2002).

One concept that is relevant for autistic users is the conceptual model of websites. A conceptual model aims to make the website imitate a real-life scenario. One example of this could be to recreate a check-in counter at an airport if the website is related to a check-in process. This way, the user will interact with the website as if it were a real-life situation.

The information architecture defines how the information is going to be displayed according to a hierarchical structure. The language, metadata and nomenclature are also defined at this point. The website needs to have descriptions, labels and terminology that identify the site. It is recommended to have a controlled vocabulary.

Guideline 6: Include help and errors feedback

Continuous feedback allowing users to correctly manage forms and fill-in options should be included. The alert messages should be clear, and the focus of the page should be on the field that requires special attention.

The colour-blind population need to have different alternatives for the presentation of information. The recommendation is to always use colour as well as an icon and text explaining the situation. The most common colour-blindness condition combination is green–red (B. Wong, 2011), and these are the colours that web forms frequently use to indicate when something is correct or incorrect. Figure 3.13 shows how colour, an icon and text are synchronised to generate a clear message for the user.

Figure 3.13 Example of different type of alerts

Web forms require a design that facilitate the understanding of missing or incorrect information when the user is filling in a web form and some information is missing or wrong. The design should not rely on colour only to alert missing or incorrect information, Figure 3.14 shows how the red colour indicates that some information is missing on the web form. It is important to not only have colour but to have text and explanations about the missing information. For example, a message should clearly express that the fields marked with red colour, or with a thicker border, and/or a message under the title, are the ones that need to be amended.

Before identifying a field as mandatory or optional, it is better to analyse if the majority of fields are mandatory, since there may not be a need to place a commonly used asterisk next to them to show that they are mandatory and, instead, to show a message announcing that "All fields are mandatory unless otherwise marked". Whenever possible, clearly explain to the user why the information is incorrect or missing.

Always allow keyboard-only navigation thought out the website as all fields must be reachable by keyboard in case the user does not have the capacity to correctly manipulate a mouse.

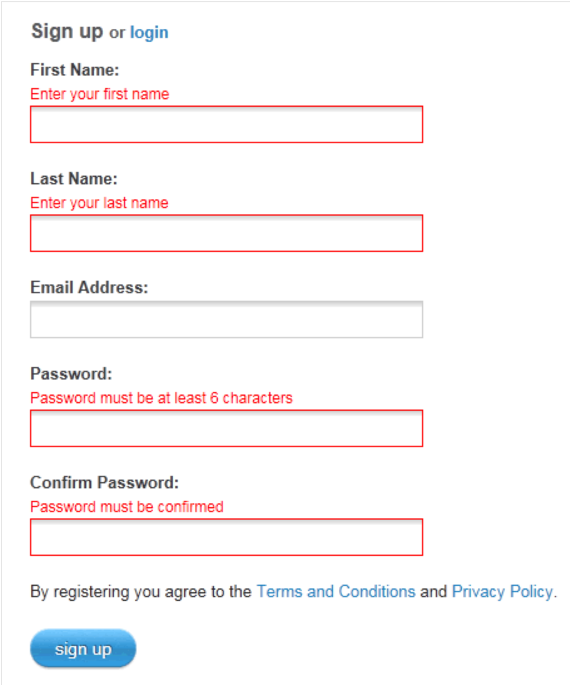


Figure 3.14 Alerts and feedback filling-in a web form

Fields requiring the creation of a new password are a distinctive example of non-accessible fields given that required text, number or symbol combinations are often not clearly explained to the user. Some passwords require lowercase and capital letters, a number, a special character, or a minimum of digits. All conditions should be clearly explained to the user. When a CAPTCHA ("Completely Automated Public Turing test to tell Computers and Humans Apart") is used to determine whether or not the user is human, it needs to be tested to be accessible, given that the requested letters or way to validate that the user is a person can be difficult to read, and hence, to write. See Figure 3.15 as an example of a CAPTCHA request that asks the user to type the two words that appear, although the image has three words and two dots. The instructions in this example are definitely not clear. This example provides the option to change the image and to request a read-aloud version of the text. This is a very useful functionality given that some users with visual impairments require sound to complete the task and provide a correct combination of letters and finally create a valid password.

Figure 3.15 CAPTCHA tool example

Guideline 7: Use literal and concrete actions language

The language used in the website should be literal and instruct the user to do concrete actions.

Autistic people can have difficulties when interpreting complex sentences, social clues and metaphors. Using simple language facilitates understanding and navigation in websites. This recommendation applies to all user interface elements: headings, icons, alerts and general content.

Icons only, without labels explaining their functionality, can cause confusion. For instance, how do you know what can you do with the icon below? (Figure 3.16)

Figure 3.16 Image of a floppy disk

The floppy disk has been used for many years as the icon for "save", but floppy disks are not in use anymore. Updated or modern "save" icons are presented as an arrow pointing down or pointing to the south direction as presented in Figure 3.17. The recommendation is for all icons to have a label explaining their functionality.

Figure 3.17 Image of an arrow pointing down as an indication of the "save" functionality

If a button or link is clickable, make it explicit by utilising different colour contrast. Links are usually blue and underlined. For example, This is a link.

When a web form contains fields corresponding to dates and phone numbers, the field should be formatted to clearly present the information to the user. US dates are presented as month, day and year. However, in Australia and Europe dates are usually formatted as date/month/year.

Telephone numbers should be formatted to present the digits as groups of three to four numbers according to the type of phone number (Figure 3.18).

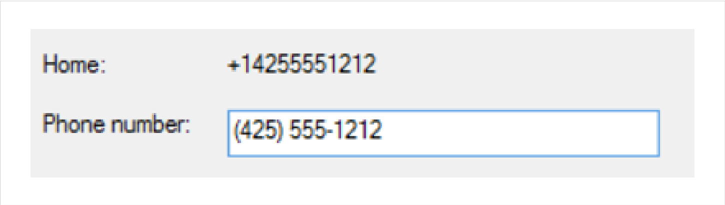


Figure 3.18 Example of telephone formatting

Guideline 8: Provide simplicity and consistency during navigation

Website navigation should be easy to follow without extensive instructions. The website should be intuitive and predictable to navigate. Generating a logical page structure will facilitate user navigation around the website. Simple and logical navigation is presented in Figure 3.19. From the Home page there is access to the second level pages, which are the most relevant for the user. More detailed information about those pages should be explained in another page; this way, the user who needs concrete information can find it in the first or second level, and another user requiring more detailed information can also find it – in the subsequent levels. The recommendation is to have maximum three levels of navigation.

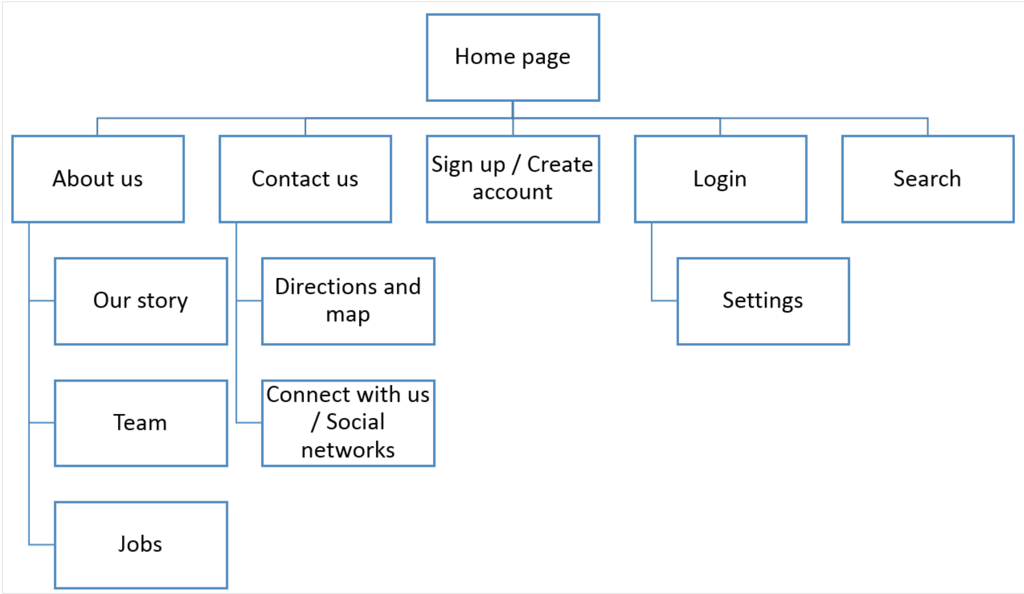


Figure 3.19 Example of a website navigation

3.3.2.4 Element 4 - Skeleton

The skeleton element in a website project integrates interface design, navigation design and information design, the three of them closely bound. Simplicity is the key message to remember as every decision is made in this element of the project.

Interface design

Interface design is the ability to create successful interfaces in which users immediately notice the important web user interface elements. The design should aim to select the right user interface elements according to the task that the user needs to accomplish. In addition, the interface design deals with the order and location of the different user interface elements in the webpage.

Navigation design

The navigation design refers to what and how user interface elements and webpages are linked in a website. Identifying where the user is at any given time, and where they can go from there, is an essential requirement when the navigation is being designed. The "site map" – a hierarchical list of webpages of a website's content designed to help users navigate the website – and the "index" of a website are part of the navigation design.

Information design

Information design describes how the website communicates ideas, specifically, how the information is to be presented so to be understood by users.

Guideline 9: Design for simplicity and consistency allowing focus and attention

The user interface design is required to be simple and easy to understand without instructions. The design of wireframes allows the final web elements to be planned and validated before they are constructed; it integrates information, interface and navigation design. There are many elements to balance so this is not an easy task, but it is one of the most important because even if the information content is excellent, if the navigation or the user interface elements are not synchronised then the content is not accessible and the user cannot enjoy the navigation. Figure 3.20 shows examples of different wireframes.

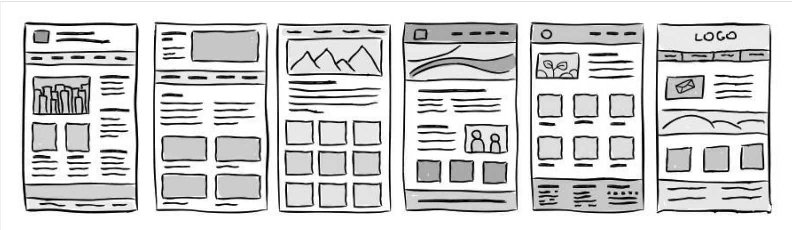


Figure 3.20 Examples of wireframes

The use of a web breadcrumb is highly recommended to facilitate navigation at every level of the website (Figure 3.21). A web breadcrumb is a type of secondary navigation scheme that reveals the user's location in a website.

Figure 3.21 Example of a breadcrumb in a website

Finally, the recommendation for an ideal home page is presented in Figure 3.22. It is simple and easy to understand and navigate. The website logo is located in the left corner, the main menu is at the same level as the logo but alighted centre to right. The main content is located in the middle of the page allowing the user to focus on it, in the first place, and secondly to scan the information on the right or below the main content. Main content usually has text and images, as autistic users focus longer on images than text (Victoria

Yaneva, Temnikova, & Mitkov, 2015), the ideal main image of the website should be related to the content and not a decorative image. Every website should have a footer at the bottom of each webpage, and it should contain shortcuts and links to the most relevant information in the website.

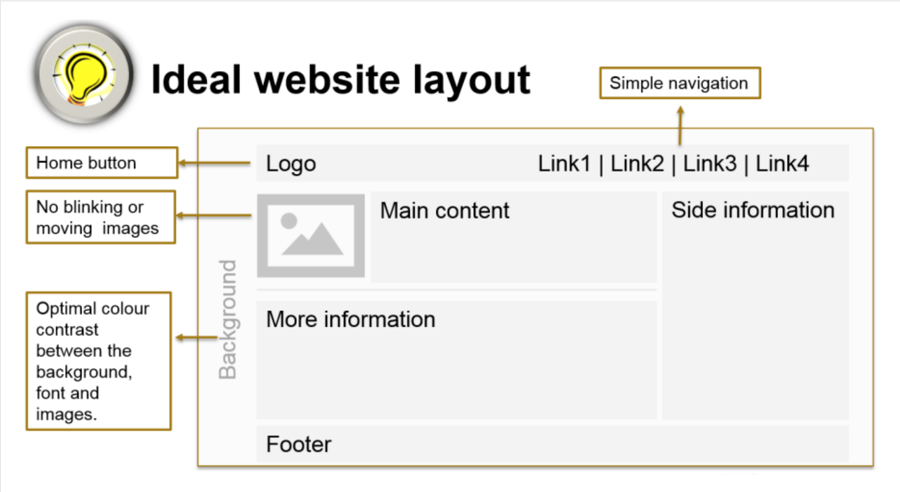


Figure 3.22 Ideal website layout

Guideline 10: Use simple graphic elements

Using graphics elements is an excellent way to communicate ideas, but the recommendation is to design them using a simple approach and to avoid complex elements that confuse the reader.

Graphic elements include but are not limited to icons, images, photographs and charts. Each element should have a label and, in the case of a picture, an alternative text. Figure 3.23 presents examples of buttons that include the icon and text.

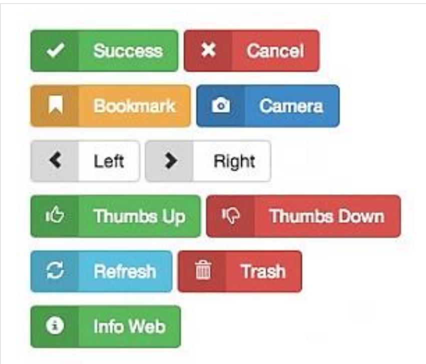


Figure 3.23 Example of buttons and icons with text

Guideline 11: Use enough spacing and size between the different user interface elements

Allowing enough spacing between different elements assures readability and comprehension. When filling forms, for instance, it is important to allow space between fields to facilitate readability, and when the user is filling a text field, it should be visibly different from other fields, allowing the user to focus on the field that needs attention. Figure 3.24 presents two different text fields of which one has a border with a different colour to hold the reader's attention.

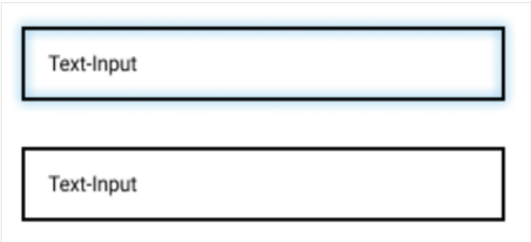


Figure 3.24 Input text example

Other user interface elements that need special attention are checkboxes and buttons, given that they need to have different contrast and colour depending on their status: normal, hover, checked, disabled, or disabled and checked. The clickable space should be big enough to facilitate their use, and usually, it is recommended to also make the label clickable so the user can select the label or the square/circle to make their selection. This recommendation is linked to having enlarged click targets. It applies to icons, buttons and links. Figure 3.25 shows various user interface elements with different colour-contrast as they are selected.

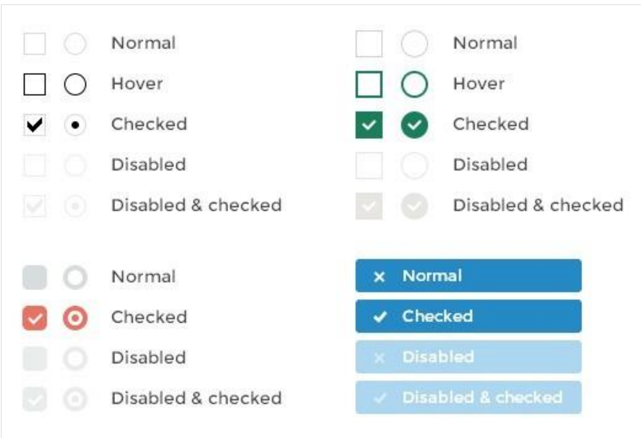


Figure 3.25 Examples of checkboxes and radio buttons

3.3.2.5 Element 5 - Surface

The surface element of a website project pertains to the visual design and how the website, as a whole, looks. From the strategic element until the skeleton element, all web design guidelines are related to planning and designing how the website should be but the surface element is when colours and design come together to create a final product.

Guideline 12: Use a colour contrast that facilitates understanding

In visual design the main tool to draw user's attention is contrast. Playing with colour contrast is important in order to guide the user from the most important content to the side elements on the website (Richardson, Drexler, & Delparte, 2014).

Colour contrast between background and font

The colour contrast is a very important aspect of a website. It allows the user to be able to read and understand the content.

Figure 3.26 shows examples of colour contrast between different background and fonts with different colour combinations. According to Murch (1985), black text on a green background is the most legible (100%), followed by blue text on a white background (94%) and white text on a black or blue background (75%). The least preferred combinations are yellow (100%) and blue (94%) font on a white background.

Black font on Yellow background	Yellow font on Black background
Red font on Yellow background	Red font on Yellow background
Blue font on Yellow background	Yellow font on Blue background
White font on Black background	Black font on White background
Red font on Black background	Black font on Red background
Blue font on Black background	Black font on Blue background
Green font on Black background	Black font on Green background
Grey font on Black background	Black font on Grey background
Blue font on White background	White font on Blue background

Figure 3.26 Examples of colour contrasts

There are online tools that validate if a colour combination has enough contrast to pass minimum levels of accessibility, some of them are:

- https://webaim.org/resources/contrastchecker/
- https://contrastchecker.com/
- http://accessible-colors.com/

These tools allow for testing if the combination between the colour of the text and the colour of the background have a contrast ratio of at least 3:1 for a person of normal vision in a normal size text, regularly set as 14 point. Text that is larger than normal size has wider character strokes and is easier to read at lower contrast. The contrast requirement for larger text is therefore lower. This allows authors to use a wider range of colour choices for large text, which is helpful in the design of pages, particularly titles. Some autistic users may prefer lower contrast given their sensibility to bright colours; the ideal implementation is to provide the option to the users to choose their preferences for colour background and font.

Application of colour contrast

The colour contrast applies to all user interface elements: icons, part of graphics, borders and gradients.

For icons the colour contrast should be sufficient between the icon information and the filling, and between the icon and the background where is placed. For example, in the following phone icon, the colour of the phone and the background colour have the right contrast. The icon needs to be placed over a background that has contrast with the blue colour used in the filling of the icon (Figure 3.27).

Figure 3.27 Phone icon with a dark background and white colour

Guideline 13: Avoid too many distracting elements and colours

The focus of each webpage should be on the most relevant information. Avoid including images and graphics that distract the attention of the user from the main content. Simplicity is always the best alternative.

One of the most important aspects to consider when designing usable web interfaces is to reduce the cognitive load (Shneiderman, 2010). The way to achieve this is by simplifying the number of items on the interface to the bare minimum, so users do not get overloaded with information and choice (Mejia-Figueroa & Juárez-Ramírez, 2017).

Non-functional guidelines

As part of the requirements for a piece of software to operate there are constraints on the services or functions offered by the system known as non-functional requirements (Sommerville, 2011). In the process of discovering how to create a good web user experience for people on the autism spectrum, some found guidelines were not related to the design and functional requirements of the website but rather related to how the website performs, and this corresponds to the non-functional level of the website. In order to understand this better, non-functional requirements should be tested for and translated into measurable requirements (Sommerville, 2011). Guidelines relevant to non-functional requirements for planning, designing and implementing desktop websites for autistic users are presented below:

- The speed of a user/event response time and the screen response time of a website should be as minimum as possible.

This guideline could be translated into a measurable requirement if response time and speed-time are defined, i.e., 2 seconds.

- The website should be reliable, with a minimum rate of failure occurrence and high availability.

This guideline could be measurable if the rate of failure is determined, i.e., errors and alerts generated when filling forms will be stored and analysed with the aim to improve the user interface element where they are generated, and as a consequence, to track if their occurrence is minimised within a certain timeframe.

- The website should be responsive.

Responsive design is related to the user interface adaptation according to the screen size and the device's orientation (Nielsen & Loranger, 2006). Dattolo and Luccio (2017) presented that most websites and applications analysed during their research were responsive. In general, web developers comply with this guideline as they understand the relevance and utility of presenting web content in different ways according to the device being used (Gardner, 2011; Martín, Haya, & Carro, 2015a).

3.4 Discussion and conclusions

Autistic users require accessible desktop websites that follow best practices, standards and guidelines for facilitating a good web user experience. Accessible websites support inclusion not only facilitating the web experience of autistic users but also that of non-autistic users.

The process of collating and chartering web design guidelines from different studies showed that the level of details and terminology used between different authors were diverse. For this reason, interpreting and implementing them could be a challenging and difficult task for web developers, with this constituting one of the biggest barriers to create accessible websites for autistic users (Loiacono & Djamasbi, 2013; Poulson & Nicolle, 2004; Schmutz et al., 2016; Szigeti, 2012).

Therefore, there was a clear and obvious need to centralise, define, and explain the web interface design guidelines using simple language to facilitate their understanding, interpretation and implementation by web developers and web content creators. It is hoped that the application of the framework presented here will improve the web user experience for autistic users when navigating desktop websites.

The scoping review presented in this chapter demonstrated an absence of consolidated and centralised web interface design guidelines for creating websites for autistic users. Hence, to facilitate the implementation, existing guidelines were grouped into 13 web design guidelines, including the tools and best practices when needed. The web design guidelines were framed into the five elements of website development: strategy, scope, structure, skeleton and surface (Garrett, 2002).

The final list of 13 web design guidelines was not an attempt to rewrite the 147 guidelines found during the scoping review but to include the key messages and recommendations from all the studies included in this research, using everyday language and examples that are familiar to most people.

These web interface design guidelines for creating desktop websites for autistic users were the input to proceed with the design of a desktop website, which will be presented and discussed in Chapter 4.

Chapter 4 An ontology-based web design framework for autistic users

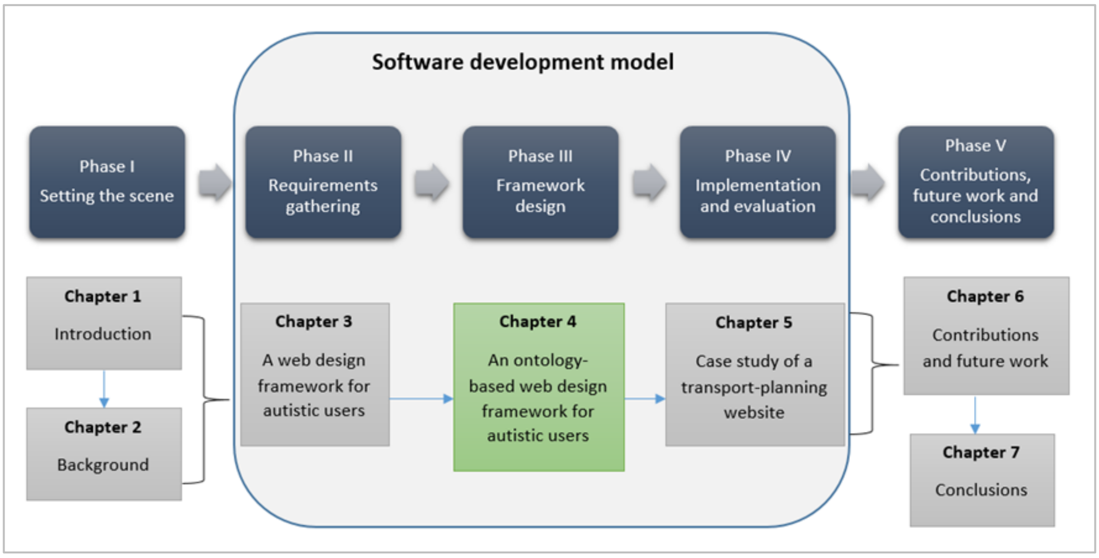


Figure 4.1 Chapter 4 in the context of the thesis structure

Continuing with the software development model, Phase III of this thesis comprises the framework design in which the current chapter, Chapter 4 (Figure 4.1), presents the ontology-based web design framework using the web design guidelines for autistic users collected in Chapter 3.

When web designers and web content creators start a new web design project, one of the most important strategies is to identify the target user and their needs (Garrett, 2002). In Chapter 2, the software design of a website based on the user-modelling concept as a way to translate the user needs into web user interface adaptations was explained. Hence, the modelling and translation of the needs and preferences of the target user into the design have been shown to be effective in generating a good user experience (Fischer, 2001; Gardner, 2011; Garrett, 2002). In the case of this research, the target user is a person with an autism diagnosis.

Also in Chapter 2, it was explained that ontologies, as a semantic web technology, are the baseline used to represent knowledge and the available concepts and taxonomies of different domains, enabling sharing and reusing the knowledge in a variety of systems (Elias et al., 2016). The original and significant contribution of this research are that using the information about the autism condition, and the needs and preferences of autistic people, the ontology-based web design framework is presented. The ontology created for this framework is called the webDesignASD ontology.

Some competency questions to be answered by the webDesignASD ontology are for example, what is a suitable font type and size for an autistic user who needs glasses to operate a computer? Which font and background colours are suitable for an autistic user who does not need glasses to operate a computer? Are moving elements such as files with gif extensions and blinking images suitable for autistic users on web interfaces? These types of questions must be answered by the developers when creating websites that cater to autistic users.

4.1 Related work

4.1.1 Web accessibility ontologies using user modelling

The approach of using ontologies in web applications to facilitate accessibility has been studied by several authors. As mentioned in the description of the problem of this thesis, to the author's best knowledge, there is no evidence of web adaptations for autistic users based on the autism ontologies (McCray et al., 2014; Mugzach et al., 2015; Tu et al., 2008). Related implementations have modelled users with special needs (S. Karim & Tjoa, 2006; M. Kultsova et al., 2016; M. Kultsova, Potseluico, Anikin, & Usov, 2019; Marina Kultsova et al., 2017; Martín, Haya, & Carro, 2015b), or users with disabilities (B. D. Romero-Mariño et al., 2017). Hence, the significant contribution this research makes is to present the ontology-based web design framework, using the webDesignASD ontology, to improve the web experience for autistic users.

Karim (2006) presented a preliminary approach where an ontology models users' impairments and a reasoner can determine the appropriate web interface visualisations, e.g. a colour blind person could require that certain colours be avoided on the screen. This approach was implemented in two ontologies, a User Interface Ontology and a User Impairments Ontology, with implementation in an information management system, called SemanticLIFE, for managing associations between the user's lifetime information items such as their emails, browsed web pages, documents under process and processes running on the user's computer (Ahmed et al., 2004). SemanticLIFE was also integrated with the user impairments ontology, through manual rules, for the creation of a hospital information system (Shuaib Karim & Tjoa, 2007) demonstrating that using semantic web rules, the heterogeneous domains of impairments and user interfaces can be linked. Their main contribution was the creation of the *InterfaceAdaptation* class as a treatment for a *Person* that has an impairment of computer systems type as shown in Figure 4.2, if a Person has an *Impairment*, then there is a *Treatment*. The *Treatment* can be an InterfaceAdaptation, which has AvailableInterfaceOptions such as textSize, textFont and textStyle.

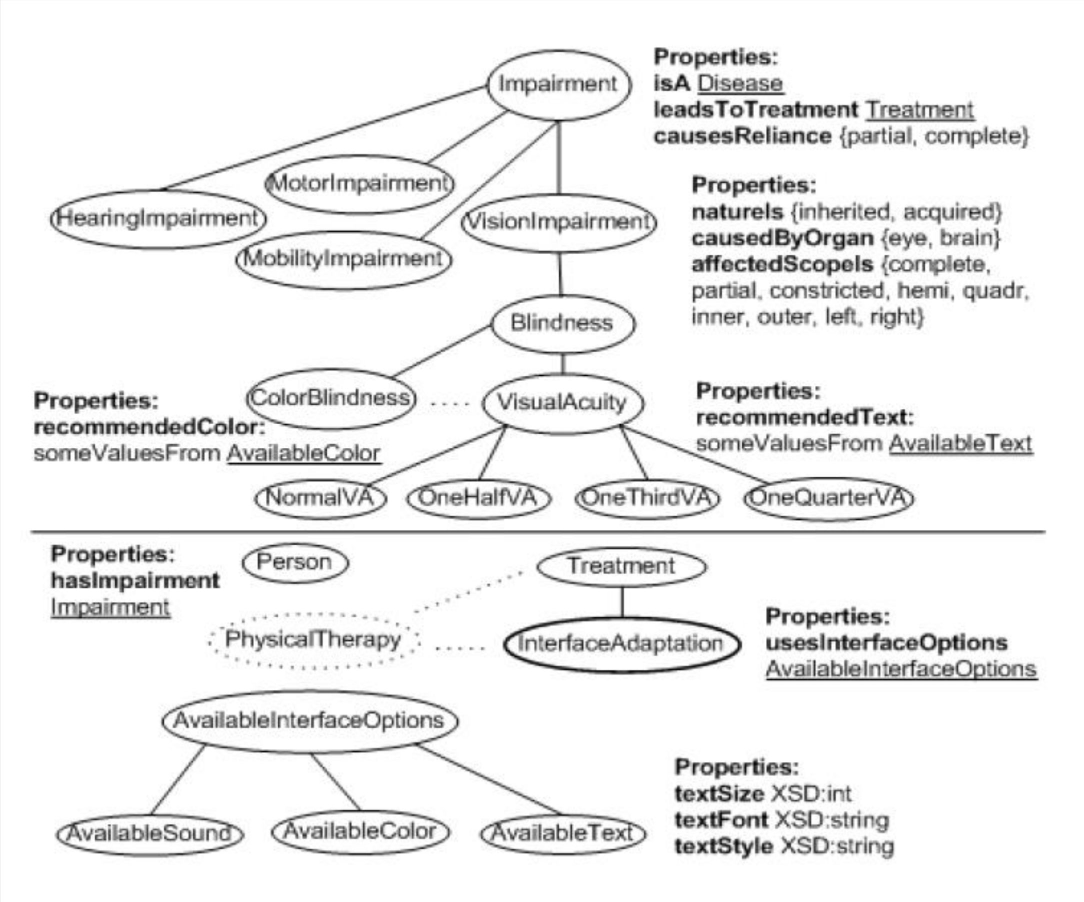


Figure 4.2 Part of Interface - User Interface Ontology (S. Karim & Tjoa, 2006)

Elias et al. (2016) studied web standards and ontologies to make e-learning and educational websites (OpenCourseWare) more accessible. They stated that disabilities can be grouped into four categories: visual, hearing, motor and cognitive impairments, and each of them has variations and severity levels that require different types of adaptations for web accessibility. They presented a list of 11 standards related to accessibility and a list of 20 accessibility ontologies. They found that most of the works studied sensory-impaired users (i.e., people with visual or hearing disabilities) and mobility-impaired users but little had been done for users with different cognitive conditions. They concluded that for web e-learning products to be accessible they require the content to be represented in several forms, the content to be validated by web accessibility guidelines with the help of ontologies, and the use of different sources of information for course management (Elias et al., 2016).

An update to this study is the AccessibleOCW ontology presented by Elias, Lohmann, and Auer (2017) which represents the learners' needs and it recommends educational resources accordingly. The knowledge in the AccessibleOCW ontology is used to infer and recommend the most appropriate resources and allow for adaptations of the website based on the learner's profile. It used and extended the ACCESSIBLE Ontology (Mourouzis, Kastori, Votis, Bekiaris, & Tzovaras, 2009) with the learner concept by adding properties that are needed to describe learners (e.g., education level, complexity level and preferred language of learning resources) (Elias et al., 2017). In a more recent update, the AccessibleOCW ontology was extended with the integration of several users' profiles such as blindness, low vision, deaf and hard of hearing, cognitive conditions, language and learning disabilities and physical disabilities. The inclusion of a preferences module was also included to finally retrieve relevant educational resources to the learner according to the selected profile and preferences (Elias, Lohmann, & Auer, 2018). The web adaptation resulted from the selection of preferences about the educational complexity (simplified/enriched), the level and language of adaptation and interface attributes related to auditory, visual and textual resources. To conclude, this series of publications (Elias et al., 2016, 2017, 2018) presented novel research using ontologies to adapt a web interface according to the user's profile but so far none of them have studied the autism condition and its relation to and impact on how the web experience can be improved for autistic users.

The ACCESIBILITIC ontology (Brunil Dalila Romero-Mariño et al., 2018) was created to represent the suitable technical support needed for an individual based on their capabilities when interacting with Information and Communication Technologies ICT's. This ontology models seven main concepts (users, impairments, disabilities and capabilities of the users, body functions, and activities and participation) and suggests the support assistant (technical support) that could be offered to the user considering their disabilities and capabilities. The ACCESIBILITIC ontology is based on the resulting ontologies from the AEGIS (AEGIS Consortium, 2012) and ACCESSIBLE (ACCESSIBLE Consortium, 2012) projects. The AEGIS ontology identifies user needs and develops accessibility support into mainstream technology devices, and its architecture consists of three categories of aspects: personal, technical and natural aspects (B. D. Romero-Mariño et al., 2017). The ACCESSIBLE ontology collects accessibility tools in order to enable organisations or individuals to obtain software products with high levels of accessibility. It consists of three dimensions: generic ontology, domain-specific ontologies and rules ontology. (B. D. Romero-Mariño et al., 2017).

4.1.2 The use of ontologies on user interfaces

This section explains some studies about user interfaces and adaptations that implement ontologies.

User interface ontologies can be characterised in several ways (Paulheim, 2011; Paulheim & Probst, 2010). There are user interface ontologies with different complexities (informal, low, medium and high), ways of interaction (none, view only, and view and edit), domains (real world, users and roles, and IT systems), presentations (none, lists, graphical, verbalised and source code), and usage time (design or run-time). When the ontology is used by the information system at run time, it is referred to as an "ontology-driven information system" (Paulheim & Probst, 2010; Ruiz & Hilera, 2006). Ontologies used in run-time often involve reasoning, and it is known that lower reaction times are essential to assuring good usability (Darejeh & Singh, 2013). For this reason, the software architecture should be carefully designed to facilitate a final implementation in which performance and timing are acceptable to the end-user. User interface ontologies can have different purposes and approach: improving the visualisation capabilities, improving the interaction possibilities and improving the development process (Darejeh & Singh, 2013). In the case of the research presented in this thesis, the purpose of the user interface ontology is to improve the visualisation capabilities according to the preferences and needs of the autistic user.

An ontology-enhanced user interface is one where the visualisation capabilities, interaction possibilities, or development process are at least enabled if not improved by the employment of one or more ontologies (Paulheim & Probst, 2010). Shahzad et al (2011) presented an ontological model where the user interface ontology (Shahzad, 2011; Shahzad et al., 2009) is integrated with the domain ontology to develop a Graphical User Interface (GUI) resulting in a User Interface Model (UIM). This approach has not been implemented yet.

Aiming to create a model with a generalised approach applicable to any domain, Hussain et al. (2018) presented a domain and device-independent model-based adaptive user interfacing methodology which is dependent on the evaluation of user context and user experience. The aim of this adaptation is to preserve usability across several contexts of use (conformed by the triplet: user, platform and environment). They implemented the adaptation on their Mining Minds platform (Banos et al., 2015), using the user model ontology (Heckmann, Schwartz, Brandherm, Schmitz, & von Wilamowitz-Moellendorff, 2005) to store information related to user cognition, physical characteristics, sensory processing and user experience, to create the adaptation rules used in the generation of adaptive user interfaces on the basis of context. An example of one of these rules is presented in Table 4.1. The ontologies generated by this study are not open-access and the author of this thesis could not obtain a copy of them to verify their results or to generate further analysis.

Table 4.1 Rule example (Hussain et al., 2018)

RuleID	Rule name	Descriptions	Event	Condition	Action
R5	Cognitive	If the user has a cognitive problem then simplify the user interface	The application contains too many different interaction elements for performing different tasks	The user has a cognitive disability	Split the UI into simplified UI having multi-steps to achieve the desired goal

4.2 Problem

There have been several attempts to design web interface adaptations for autistic users but none have explored the possibility of modelling the autism condition based on the web design requirements, and their implications for different user interface elements, to create web user interfaces that are more accessible for autistic users.

The use of semantic web technologies, such as ontologies, is a new and novel way that provides a way to reuse, share and explore knowledge about the autism condition and provides a method to adapt web interfaces with the aim of creating a good user experience for autistic users. The research presented within this thesis steps into the gap surrounding autistic users demonstrating a significant contribution to web accessibility for individuals on the autism spectrum.

4.3 Method

The objective of this chapter is to create the ontology-based web design framework for autistic users using semantic web technologies.

The software architecture of a website using semantic web technologies has the application layer which corresponds to the web user interface that the autistic user manipulates and navigates. It is accessed by any web browser on a computer connected to the Internet. The semantic web processing layer hosts the web server and the triple store. The triple store is the database where the triples (subject–predicate–object entities) as Resource Description Framework (RDF) files are stored (Segaran, Evans, & Taylor, 2009). Finally, the ontology layer hosts the ontologies that are used to create and adapt the web interface.

To create the ontology-based framework, a new ontology called webDesignASD was needed. The webDesignASD is one of the significant contributions of this research. The process of designing software using ontologies requires identifying the objective and scenarios where the ontology will be used (Ruiz & Hilera, 2006). To create a new ontology, such as webDesignASD, it is necessary to define the classes and properties of each concept describing its features, attributes and restrictions (Noy & McGuinness, 2001). The way to create and expand ontologies is to: follow the general structure determining the domain and scope of the ontology, consider reusing existing ontologies, enumerate important terms in the ontology, define the classes and the class hierarchy, define the properties of the classes (called slots), define the facets of the slots, and create instances (Noy & McGuinness, 2001).

There are several methods to create ontologies. According to Brunil Dalila Romero-Mariño (2019), from the most to the least relevant methods they are: the NeOn (Suárez-Figueroa, Gomez-Perez, & Fernandez-Lopez, 2012), METHONTOLOGY (Fernández-López, Gómez-Pérez, & Juristo, 1997), DILIGENT (Pinto, Staab, & Tempich, 2004), On-To-Knowledge (Sure et al., 2003), Fox and Gruninger (Fox & Grüninger, 1997) and Uschold and King (Uschold & King, 1995). The three most relevant are explained below:

- NeOn (Suárez-Figueroa et al., 2012) was the first ontology to include the concept of ontology networks (several ontologies interrelated). It is based on scenarios as different ways to create ontologies and ontology networks. It is a scenario-based methodology that supports the collaborative aspects of ontology development and reuse, as well as the dynamic evolution of ontology networks in distributed environments.
- METHONTOLOGY (Fernández-López et al., 1997) promotes the creation of new ontologies from scratch by reusing and reengineering existing ontologies. It presents a unique life cycle based on the evolution of prototypes.
- DILIGENT (Pinto et al., 2004) is based on the collaborative and distributive environment of a team creating new ontologies. This method emphasises tracking changes.

4.3.1 The NeOn methodology

As presented in Section 2.2.4, there are several ontologies related to web accessibility for users with different cognitive conditions such as autism. To reuse and expand those existing ontologies and creating the webDesignASD ontology, this thesis used the NeOn methodology, which provides the elements for ontology engineering (Suárez-Figueroa et al., 2012) and it has been used in many ontology implementations with good results (Pratiwi, Xu, Li, Trost, & Tjondronegoro, 2018; Brunil Dalila Romero-Mariño et al., 2018). The NeOn methodology framework provides (a) a glossary of processes and activities involved in the development of ontologies, (b) two ontology life cycle models (Waterfall or iterative-incremental model) and (c) a set of methodological guidelines for different processes and activities (Suárez-Figueroa et al., 2012). NeOn has a set of nine scenarios for building ontologies and ontology networks (Suárez-Figueroa, 2012; Suárez-Figueroa et al., 2012) as presented in Figure 4.3:

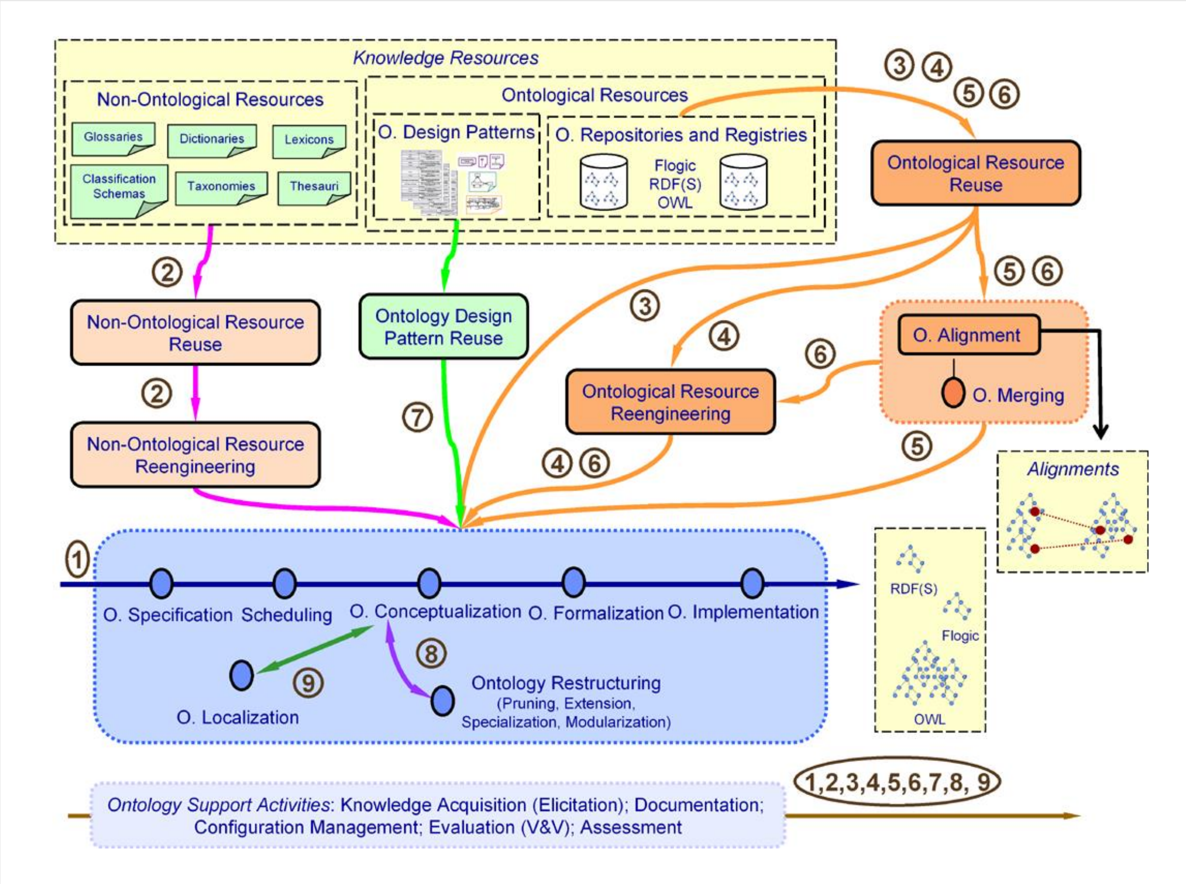


Figure 4.3 NeOn Methodology: the nine scenarios for building ontologies and ontology networks (Suárez-Figueroa et al., 2012)

The nine Neon scenarios are:

Scenario 1: From specification to implementation. This scenario implies the creation of a new ontology from scratch without using existing knowledge.

Scenario 2: Reusing and re-engineering non-ontological resources. Non-ontological resources are for example a glossary, lexicon, thesauri, or a classification scheme.

Scenario 3: Reusing ontological resources. This implies the use of existing ontologies in the creation of a new ontology.

Scenario 4: Reusing and re-engineering ontological resources. This refers to both reusing existing ontological resources and making a process of analysis as well as re-engineering them with the aim to create a new ontology.

Scenario 5: Reusing and merging ontological resources. In this scenario the new ontology is the result of merging two or more existing ontological resources.

Scenario 6: Reusing, merging and re-engineering ontological resources. This scenario is similar to Scenario 5, however, in this case developers decide not to use the set of merged resources as it is, but to re-engineer it.

Scenario 7: Reusing ontology design patterns (ODPs). The ontology developers access ontology design patters and reuse them in the new ontology.

Scenario 8: Restructuring ontological resources. Ontology developer's restructure (modularising, pruning, extending and/or specialising) ontological resources to be integrated in the ontology network being built.

Scenario 9: Localising ontological resources. Ontology developers adapt an existing ontology to other languages and culture communities, thus producing a multilingual ontology.

This thesis mainly employed Scenarios 2 and 4 of reusing and re-engineering non-ontological resources and current ontological resources, resulting in a network of ontologies that represents the domain of web accessibility for autistic users. The NeOn methodology suggests that several scenarios could be needed at different stages of creation of the new ontology but the results of any other scenario should be integrated in the corresponding activity of Scenario 1. The core activities of the Scenario 1 are: (1) ontology requirements specification: this includes the purpose, scope and ontology requirements, (2) scheduling: this corresponds to planning human resources and the lifecycle needed for the ontology project, (3) ontology conceptualisation: here, knowledge is organised in meaningful models, (4) formalisation: the conceptual model is transformed into semi-computable model and (5) implementation: the computable model is generated.

The NeOn methodology was used for creating the webDesignASD ontology. Non-ontological knowledge in the domain of web accessibility for autistic users was used as well as reusing and expanding the ontological resources such as the autism ontology (Mugzach et al., 2015) and the ACCESSIBILITIC ontology (Brunil Dalila Romero-Mariño et al., 2018).

The free and open-source ontology editor Protégé (Stanford University, 2019) was used to manipulate the ontologies.

4.4 Results

4.4.1 Ontology requirements specification

The main objective of the new ontology, called webDesignASD, was to model the autistic user and their preferences and needs onto different elements of web user interfaces in order to generate reasoning about those preferences and to make it possible to adapt their web interface to make it more accessible and usable for autistic users. The ontology was implemented using the Ontology Web Language OWL language (Bechhofer, 2009) and the reasoner HermiT version 1.3.8.413 (Glimm, Horrocks, Motik, Stoilos, & Wang, 2014), using the open-source ontology-development tool Protégé (Gennari et al., 2003) version 5.0 [1]. The language of implementation was British English as this thesis is developed in Australia. The ontology is available to download following this link: https://github.com/clau1228/PhD.

Making the web interface more accessible and usable is achieved in accordance with the level of functioning of the user. The level of functioning is the outcome of complex interactions between health condition, body functions and structures, activities and participation, environmental factors and personal factors (Bölte et al., 2014). Hence, an improved level of functioning of autistic users when using web interfaces is an outcome from the proposed ontology-based web design framework. As described by the International Classification of Functioning ICF (World Health Organization, 2002), a person can have a health condition, which affects some body structures and functions, which are related to some activities and, given their deficit, they restrict the user of participating in some activities. Body functions, activities and participation are directly affected by personal factors of the individual and by the environmental factors given by the society they live in.

The main concepts involved in the creation of webDesignASD are:

User: describes the person who needs to use a web interface. The person has disabilities and capabilities, and a diagnosis of autism in the case of this research.

Impairment: as described by the International Classification of Functioning and Impairments ICF (World Health Organization, 2007), impairments are problems in body function or structure that represent a significant deviation or loss. For the

[1] Further information about the Protégé ontology editor at https://protege.stanford.edu/

classifications of body function and structure, the primary qualifier indicates the presence of an impairment and, on a five point scale, the degree of the impairment of function or structure (no impairment, mild, moderate, severe and complete). In the case of the Activity and Participation, the qualifiers are performance and capacity (World Health Organization, 2002). Relevant to this research are the five impairments categories (ACCESSIBLE Consortium, 2012; AEGIS Consortium, 2012): vision, upper limb, cognitive, hearing and communication.

Disability: A disability describes subtypes of impairments. Disability can be temporary or permanent, and it can be partial or total. Each disability has a group of associated functional limitations, which contains the ICF classification (World Health Organization, 2002).

Capability: Capability refers to the user's capabilities regardless of the user's disabilities (B. D. Romero-Mariño et al., 2017) with respect to the use of web interfaces. The relevant capabilities to be included in the ontology are the technology expertise of the user, e.g., typing speed and the capacity to use mouse and keyboard and their visual capability (good, poor, or legally blind).

Body function: body functions are physiological functions of body systems (including psychological functions) (World Health Organization, 2002). Relevant to the use of web user interfaces is the seeing function, especially the quality of vision related to colour vision (There are different types of colour blindness).

Web adaptation: adaptations made on web interfaces to facilitate their navigation and understanding by autistic users. The web adaptation is linked to a web design guideline and a user profile according to that person's impairments, disabilities and capabilities.

The webDesignASD ontology is designed to model the following information and relationships:

- A user has age, has gender, has location and has technology-usage knowledge.
- A user has an autism diagnosis, which is a disability.
- A user has dyslexia, which is a disability.
- A user has different vision levels: normal (does not need glasses to operate a computer), low visual impairment (the user uses glasses to operate a computer), or a high visual impairment (the user is legally blind).
- Autism is a cognitive impairment.
- One disability is associated with a functional limitation.

- A user has capabilities.
- One disability affects activity limitations. Activity limitations are difficulties that a user may have in executing everyday life tasks.
- An activity limitation is due to one or more disabilities.
- One disability requires one web adaptation and one web adaptation is intended for a disability.
- A web adaptation has corresponding web design guidelines.
- A guideline affects some user interface elements.

In Chapter 3, the web design guidelines to make desktop websites more accessible for autistic users were listed. These guidelines are translated into web design ontology requirements, where possible, as presented in Table 4.2.

Table 4.2 Web design guidelines as ontology requirements

Web design guideline		Web design ontology requirement
1	Avoid the use of moving elements	The user interface element *Image* can be static or animated.
2	Provide enough time on general tasks	The time limit to fill web forms or other activities on user interfaces can be defined as none or it can have a defined duration.
3	Allow customisations according to user preferences	User can select different options related to: font type, font colour, font size, font spacing, background colour and style of button.
4	Provide multiple source of information	This is a content requirement, there is not a user interface element to validate this guideline.
5	Use simple language facilitating readability	Sentences should be readable and understandable for a user with reading level equal to Year 7.
6	Include help and errors feedback	This is a content requirement, there is not a user interface element to validate this guideline.
7	Use literals and concrete actions language	This is a content requirement, there is not a user interface element to validate this guideline.
8	Provide simplicity and consistency during navigation	This is a visual requirement, there is not a user interface element to validate this guideline.
9	Design for simplicity and consistency allowing focus and attention	This is a visual requirement, there is not a user interface element to validate this guideline.
10	Use simple graphic elements	This is a visual requirement, there is not a user interface element to validate this guideline.
11	Use enough spacing and size between the different user interface elements	This is a visual requirement, there is not a user interface element to validate this guideline.
12	Use a colour contrast that facilitates understanding	The colour contrast between font and background should comply with international standards of readability as the WCAG (W3C, 2019d).
13	Avoid too many distracting elements and colours	This is a visual requirement, there is not a user interface element to validate this guideline.

The webDesignASD ontology answers the following competency questions:

- What is a suitable font type and size for an autistic and dyslexic user who needs glasses to operate a computer?
- Which font and background colours are suitable for an autistic user who does not need glasses to operate a computer?
- Are moving elements such as files with gif extensions and blinking images suitable for autistic users on a web interface?

The web design guidelines found in Chapter 3 aim to facilitate the understanding and navigation of web interfaces by autistic users. Those guidelines can be translated into adaptation rules:

Rule 1:

Condition: the user is autistic.

Action: the web interface needs to be adapted to comply with the following criteria: no moving elements, no limitation on time, the font and colours should be able to be personalised, icons should have labels, simple texts understandable for Year 7 users, and a colour contrast between elements that facilitate readability and understanding.

Rule 2:

Condition: the user is autistic and dyslexic

Action: the web interface needs to be adapted under all actions on Rule 1 and the type of font must be compatible for someone with dyslexia.

As each autistic user has their own preferences and needs, the user can change several aspects from the web interface to make it more accessible and appealing to them.

Rule 3:

Condition: the user is autistic and has set their preferences

Action: The web interface should be adapted according to the user’s preferences and where no preferences have been set, the Rule 1 profile should be implemented.

4.4.2 Scheduling

The ontology developed in this thesis followed an iterative lifecycle where analysis, design, implementation and testing activities where done several times until the research questions were answered by the presented model. When complementing ontologies were found, they were integrated into the model.

4.4.3 Ontology conceptualisation

Ontology conceptualisation refers to the activity of organising and structuring the information (data, knowledge, etc.) into meaningful models at the knowledge level according to the ontology specification (NeOn Project, 2007). It includes knowledge acquisition, integration and evaluation.

The knowledge resources used to create the webDesignASD ontology include non-ontological knowledge and existing ontologies related to the domain of web accessibility for autistic users. The non-ontological knowledge resources identified are the web design guidelines collected in Chapter 3. They need to be integrated into the new ontology as the preferred profile for an autistic user.

Presented by B. D. Romero-Mariño et al. (2017), the ACCESSIBILITIC ontology (Brunil Dalila Romero-Mariño et al., 2018) is the most complete ontological implementation related to web accessibility. It was made after a reengineering process over the AEGIS/ACCESSIBLE ontology. The ACCESSIBILITIC ontology modelled users with disabilities and the technical support needed according to their disabilities. The focus on technical support is not relevant to this thesis, but the web adaptation is the relevant condition in the case of the webDesignASD ontology. This ontology also helps to answer questions that can be relevant to this research, for example: What impairments does the user have according to a diagnosed disability?

The autism condition has been modelled as an ontology in the most complete form by MacCray et al. (2014) because this model extends the Tu et al. ontology (2008) including OWL class definitions representing DSM-IV diagnostic criteria for autistic disorder and ASD criteria for Autism Spectrum Disorder OWL Reasoners. This research uses this model and expands it to create an ontology-based autistic-specific web design framework.

This is the list of existing ontologies that are linked with the domain of this research:

- Autism Ontology (Mugzach et al., 2015)
- ACCESIBILITIC Ontology (Brunil Dalila Romero-Mariño et al., 2018)

AdaptUI Ontology (Eduardo Castillejo, Aitor Almeida, & Diego López-De-Ipiña, 2014), which is a proposed ontology. The main concepts modelled were body function, user, impairment, disability, capability and web adaptation. The architecture comparison between reused classes from different ontologies and the webDesigASD ontology is shown in Table 4.3. The first column lists the class name in the webDesignASD ontology, the second column describes the source ontology, and the third column describes the name of the class from the source ontology.

Table 4.3 Architecture comparison of reused ontologies on the new webDesignASD ontology

webDesignASD Classes	Source Ontology	Source class / Concept
User	ACCESIBILITIC Ontology	Customer
Impairment	Accessible Ontology	Impairment
Disability	Accessible Ontology	Disability
Capability	ACCESIBILITIC Ontology	Capability
Body function	Accessible Ontology	Body function

The class *User* was renamed from the *Customer* class in the ACCESSIBILITIC ontology and, as the target user of this ontology is the autistic user, it can be related to several ontologies that have used or defined an autistic person. Table 4.4 presents the ontology classes or ontology individuals that have referred to an autistic person and to which ontology they correspond.

The classes *Impairment*, *Disability* and *Capability* were imported from the ACCESSIBILITIC ontology. The "Web Adaptation" class is a new class that includes the web design guidelines for desktop websites for autistic users, and contains the autismProfile class where the basic user interface characteristics are stored. The *Web Adaptation* class also has a property called "is preferred" (isPreferred) linking the user interface elements with the user, and the inverse property corresponds to "has preference" (hasPreference).

The main classes used in webDesignASD are presented in Figure 4.4. They are *BodyFunction*, *Capability*, *Disability*, *Impairment*, *User* and *WebAdaptation*.

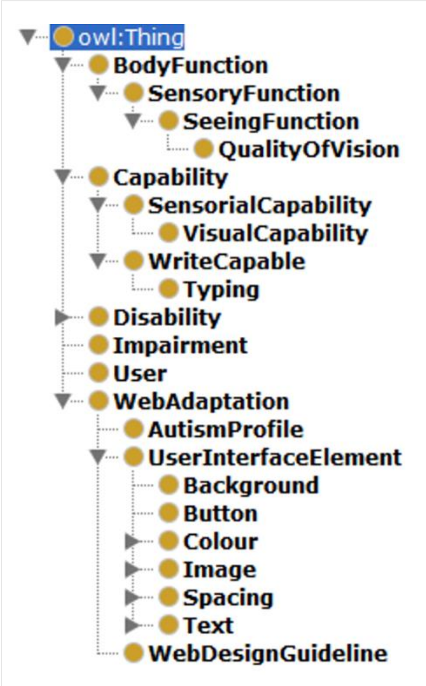


Figure 4.4 webDesignASD ontology classes

Table 4.4 Relevant ontologies that refer to the autism condition

Ontology	Class (C) or Individual (I)	URL
Autism DSM-ADI-R ontology[1]	Autism (C)	http://purl.org/autism-ontology/1.0/autism-rules.owl#Autism
Medical Dictionary for Regulatory Activities Terminology (MedDRA)[2]	Autism (C)	http://purl.bioontology.org/ontology/MEDDRA/10003805
International Classification of Diseases, Version 10[3]	Childhood autism Asperger's syndrome	http://purl.bioontology.org/ontology/ICD10/F84.0 http://purl.bioontology.org/ontology/ICD10/F84.5
Interlinking Ontology for Biological Concepts[4]	Autism (C)	http://purl.jp/bio/4/id/200906044868102156
Human Phenotype Ontology[5]	Autism (C)	http://purl.obolibrary.org/obo/HP_0000717
Pediatric Terminology[6]	Autism (C)	http://www.owl-ontologies.com/Ontology1358660052.owl#Autism
Disease core ontology applied to Rare Diseases[7]	Autism (C)	http://www.limics.org/hrdo/rdfns#pat_id_312
Human Disease Ontology8	autism spectrum disorder (C)	http://purl.obolibrary.org/obo/DOID_0060041
ACCESSIBLE Ontology	Autism (I)	http://www.AccessibleOntology.com/GenericOntology.owl#Autism
Human Disease Ontology9	autistic disorder (C)	http://purl.obolibrary.org/obo/DOID_12849

[1] Link to the ontology: http://bioportal.bioontology.org/ontologies/ADAR
[2] Link to the ontology: http://bioportal.bioontology.org/ontologies/MEDDRA
[3] Link to the ontology: http://bioportal.bioontology.org/ontologies/ICD10
[4] Link to the ontology: http://bioportal.bioontology.org/ontologies/IOBC
[5] Link to the ontology: http://bioportal.bioontology.org/ontologies/HP
[6] Link to the ontology: http://bioportal.bioontology.org/ontologies/PEDTERM
[7] Link to the ontology: http://bioportal.bioontology.org/ontologies/HRDO
[8] Link to the ontology: http://bioportal.bioontology.org/ontologies/DOID
[9] Link to the ontology: http://disease-ontology.org/

4.4.3.1 Sequence diagram

The sequence diagram of the adapted user interface based on the autistic user profile is presented in Figure 4.5. The user starts completing their basic information, and with this information the system searches their profile and presents an interface in accordance with it and asks for the user's preferences. The user selects their preferences, the profile is updated and a new interface is presented according to the profile and preferences. Preferences overwrite profile conditions, e.g., the user profile indicates that the font size should be normal, but the user selected in his preferences a font size large. The system presents the font following the user preferences, in this case, large font.

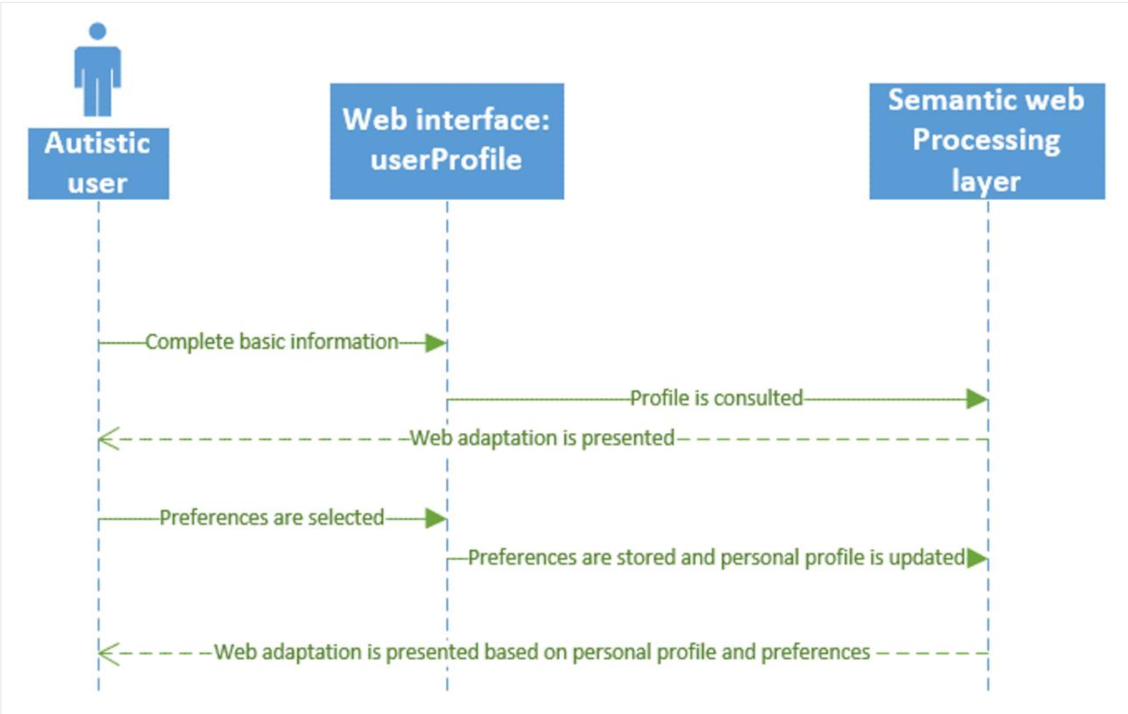


Figure 4.5 Sequence diagram of the ontology-based web design framework

Complete basic information

The user needs to complete their basic information to allow the web interface to adapt according to their profile.

Unique user ID: This is a consecutive number created by the system.

Date of birth: the date of birth is stored to calculate the age of the user.

Health condition: the system stores if the user is autistic, non-autistic, dyslexic, or any combination between them.

Gender: the user needs to select if they recognise themselves as female, male or other. This is relevant for this research because autism presents differently between genders in terms of functioning and disabilities, and these differences are dependent on age range and intellectual capacity (De Schipper et al., 2016).

Vision condition: the system stores if the user has normal vision (They do not need eyeglasses), low visual impairment (They use eyeglasses to read/drive), or a high visual impairment (they are legally blind in Australia).

Select user interface preferences

The user can select his web interface preferences of: background colour, font colour, size and type, the paragraph line spacing and the style of buttons. The web interface has the following configurations:

- Colour of font and background between these options: black, white, grey, yellow.
- Type of font between these options: Arial, Verdana, Dyslexic
- Font size between these options: small, medium, large
- Line spacing between these options: 1.0, 1.5, 2.0
- Button colour style between these options: colour filled or only border.
- The default profile has been defined as follow:
- Colour of font: black
- Colour of background: grey
- Type of font: Arial
- Size of font: small
- Paragraph line spacing: Normal (1.0)
- Type of button: Colour filled

According to the information provided by the user, the web interface adapts as follows:

- If the user selected low vision impairment, the font size changes to normal, and if a high visual impairment was selected the font size changes to large.
- If the user selected that they have dyslexia, the presented font is adapted to be more accessible and readable by dyslexic users. The presented font is changed for “Dyslexic” and upsized to normal size.

4.4.3.2 Meaningful models

The webDesignASD ontology conceptualisation is modelled as presented in Figure 4.6. All first level, the webDesignASD ontology classes, *User*, *Impairment*, *Capability*, *Disability*, *BodyFunction* and *WebAdaptation*, are part of (or subclasses of) the main class owl:Thing.

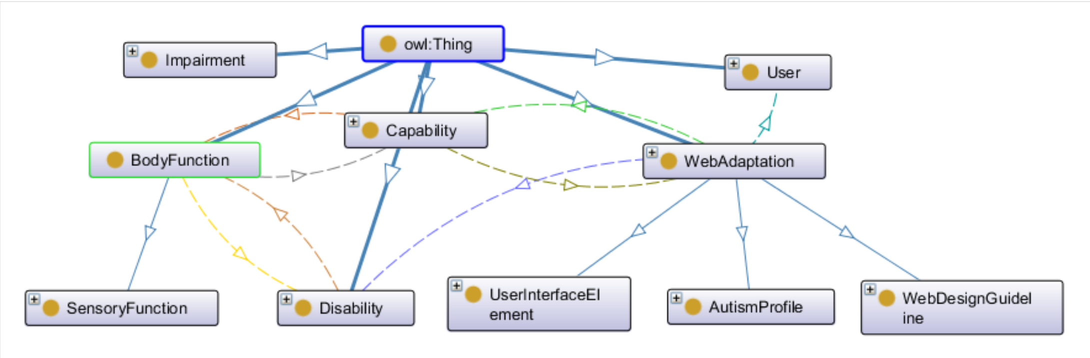


Figure 4.6 webDesignASD Ontology conceptualisation

The model of classes and sub-classes of webDesignASD is presented in Figure 4.7.

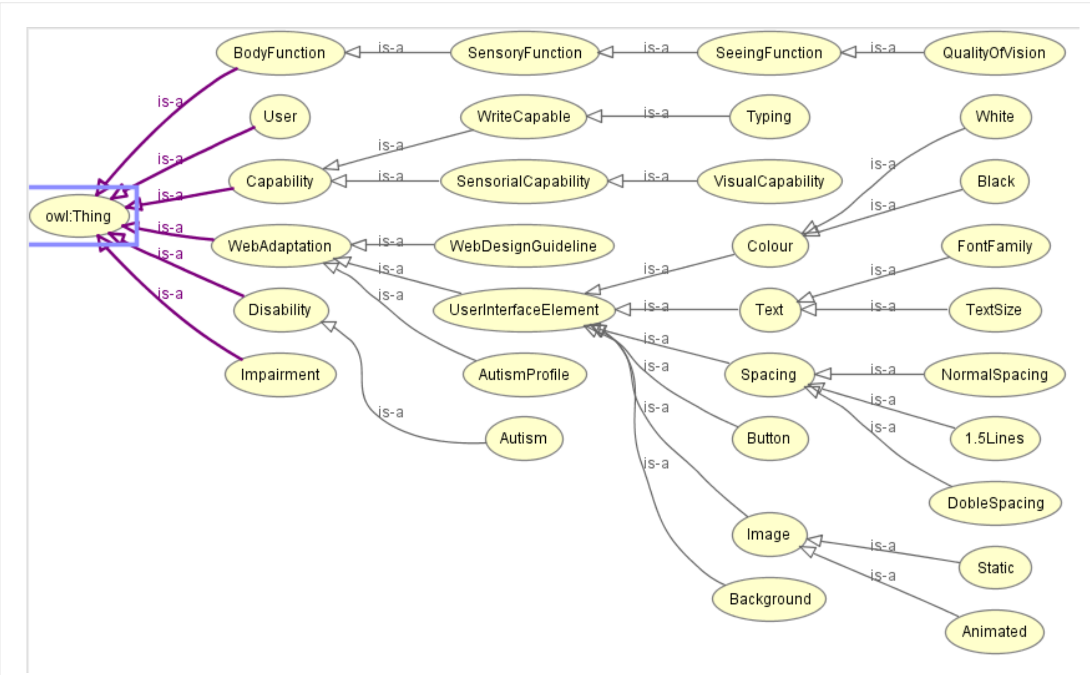


Figure 4.7 webDesignASD ontology classes and sub-classes

The full model of the webDesignASD ontology is presented in Figure 4.8. It is centred in the *User* class and shows the main classes and the relations they have with other entities.

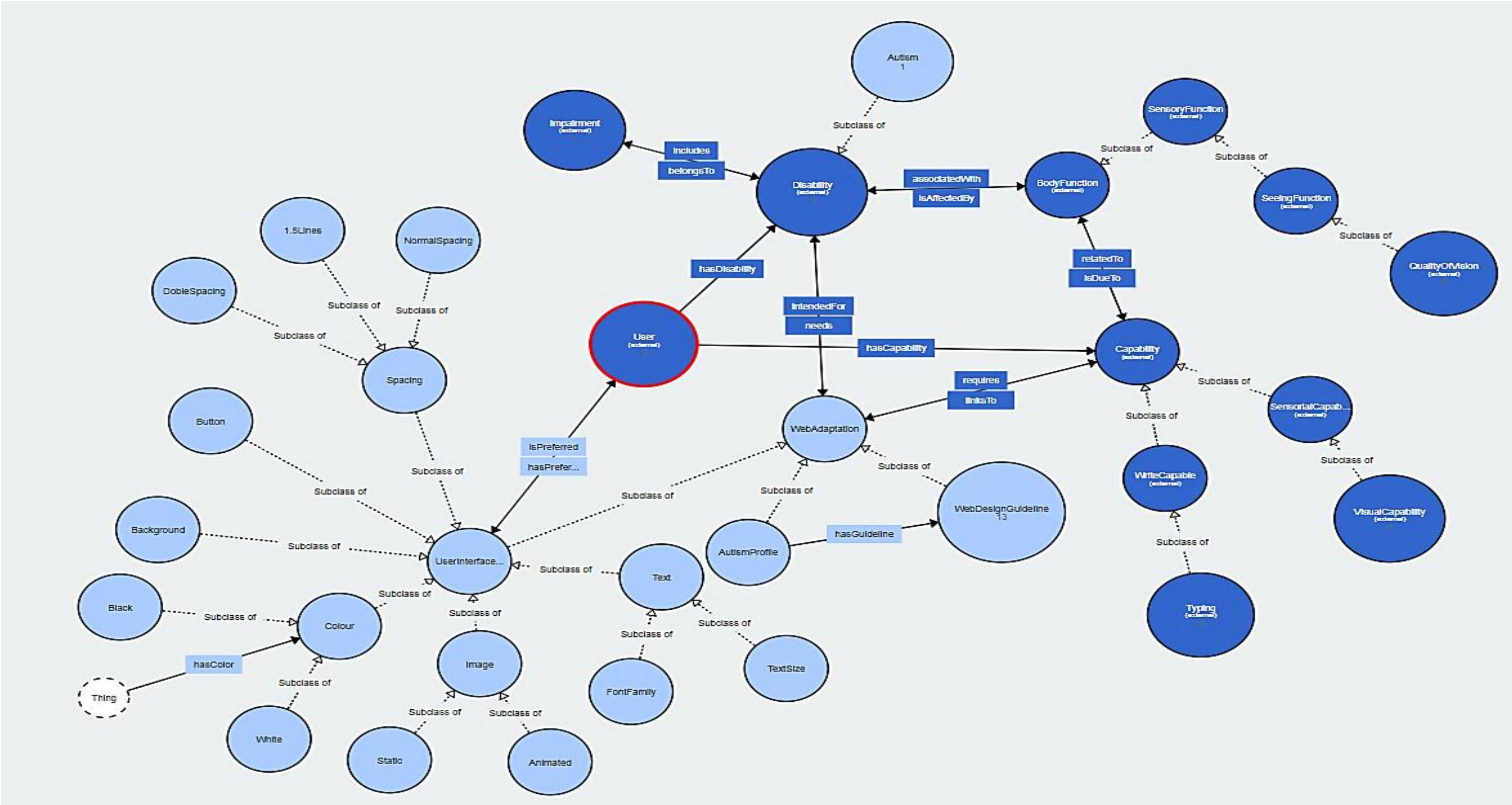


Figure 4.8 webDesignASD ontology model

The model applied to a particular autistic user who was born in 1998, the gender is male, the current location is Perth, and normal vision is presented in Figure 4.9, in which the main six classes of the ontology are presented in colour blue, and the complementing classes related to the user interface elements and guidelines are presented in colour green.

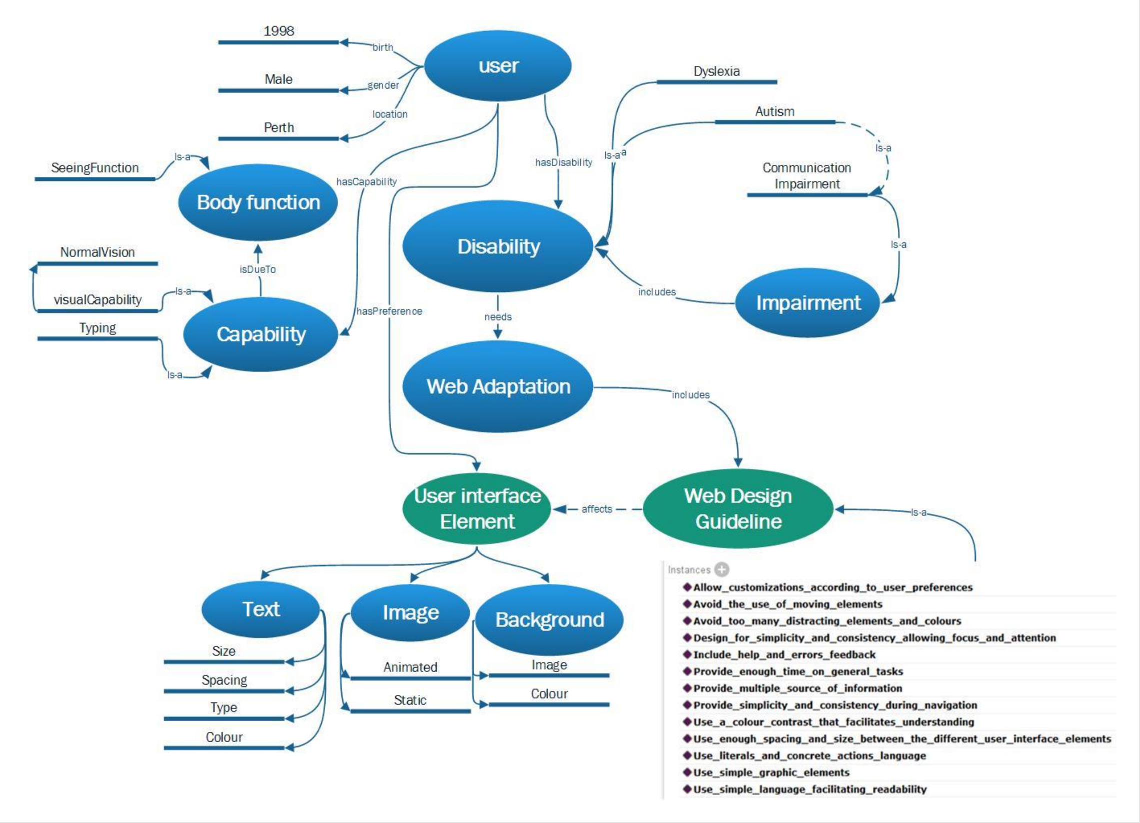


Figure 4.9 webDesignOntology model implemented in a particular user

4.4.4 Ontology formalisation

The formalisation of the ontology implies transforming the conceptual model into a semi-computable model (Suárez-Figueroa et al., 2012). Protégé provides the tools to create the classes, object and data properties of the ontology needed to compute and infer using the different ontology elements. The webDesignASD ontology (webDesignASD.owl) is presented in Appendix D.

4.4.4.1 Classes

Detailed information about the webDesignASD ontology classes is presented below:

User class

This class is based on the definition of *User* of the ACCESIBILITIC ontology. It has Annotation Properties for complementing the documentation: hasName and hasDescription, as presented in Figure 4.10. The data property assertions of a user are: hasAge, hasbirthYear, hasGender, hasLocation, TechnologyUse. An example of the property assertions for User_01 is presented in Figure 4.11. This class is related to the *Capability* and *Disability* classes through the object properties hasCapability and hasDisability, this is shown in Figure 4.12.

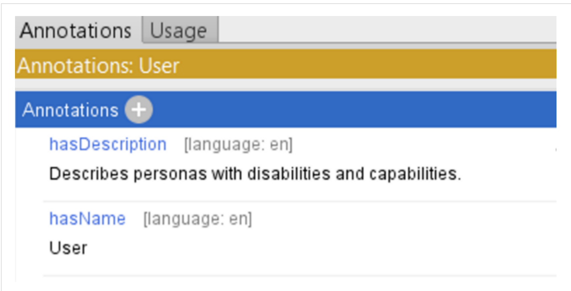


Figure 4.10 User class annotation properties

Figure 4.11 Example of property assertions User_01

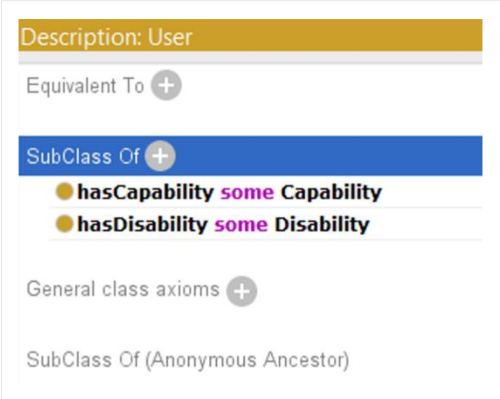


Figure 4.12 Object properties used by the User Class

Impairment class

The *Impairment* class is based on the definition of the ACCESIBILITIC ontology. An impairment is a problem in a body function or structure so we can relate a disability to a certain impairment (Figure 4.13). The impairment related to the autism condition is a communication impairment (Communication_Impairment), presented in Figure 4.14.

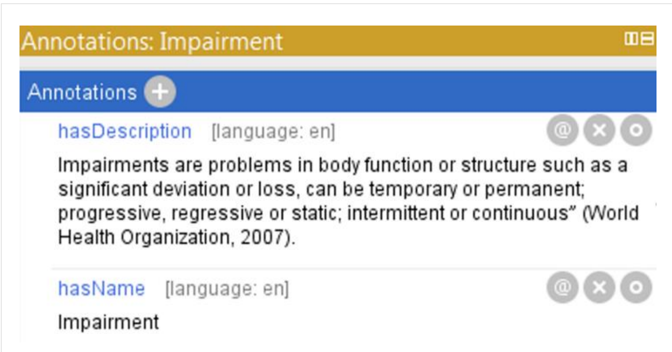


Figure 4.13 Impairment class annotations, name and description

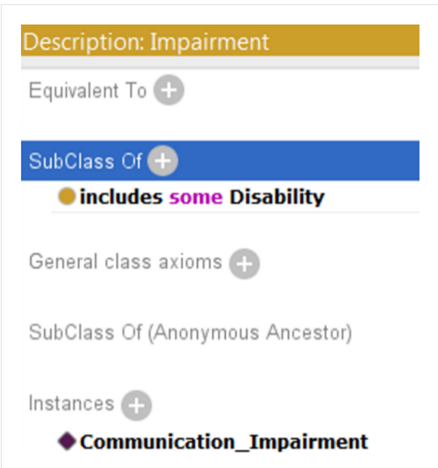


Figure 4.14 Objective property and instance of the Impairment class

Disability class

This thesis has presented how people on the autism spectrum require certain web interface adaptations for improving their capacity to access the Web. The class *Disability* is related to the Web Adaptation class though the object property *needs*, check this in Figure 4.15. For example: autism, colour blindness and dyslexia are instances of the disability class. They are related to body functions; they are a kind of impairment and they require web adaptations (Figure 4.16).

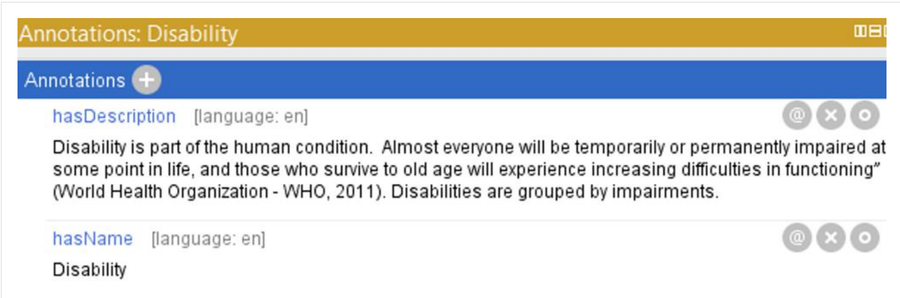


Figure 4.15 Disability class annotations, name and description

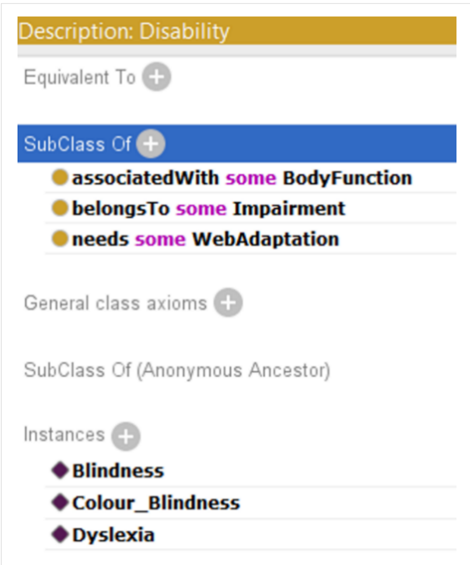


Figure 4.16 Disability class associated with other classes and some instances

BodyFunction class

The *BodyFunction* class is based on the definition of the ACCESIBILITIC ontology and has the annotations of name and description (Figure 4.17). A body function is related to some capabilities and it is affected by some disabilities, and this relation is presented in Figure 4.18.

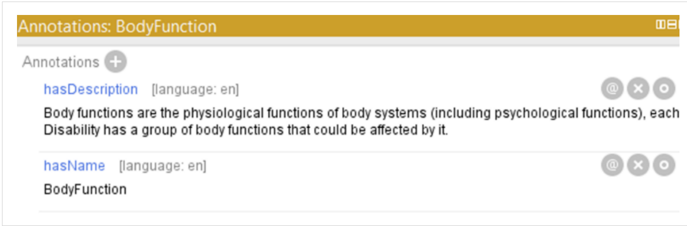


Figure 4.17 BodyFunction class annotations, name and description

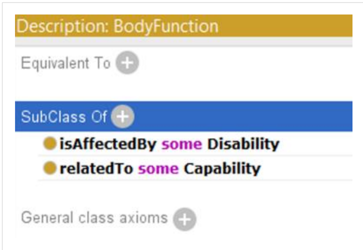


Figure 4.18 BodyFunction class related with other classes

Capability class

The *Capability* class is based on the definition of the ACCESIBILITIC ontology. It has the annotations name and description (Figure 4.19), and it is related with the *BodyFunction* class by the annotation property isDueTo. In the case of this research the *supportAssistance* class in ACCESIBILITIC was changed to Web Adaptation, as presented in Figure 4.20. The *Capability* class has two sub-classes; the sensorial capability subclass, which indicates the user's ability to see and the write capable subclass, which indicates their typing capability. The visual capability has three levels, and they were created as ontology individuals (good, poor or legally blind). The typing capability has two levels (easy typing and difficulty typing), so they were created as ontology individuals. They were included in the ontology because they are related to web user interfaces.

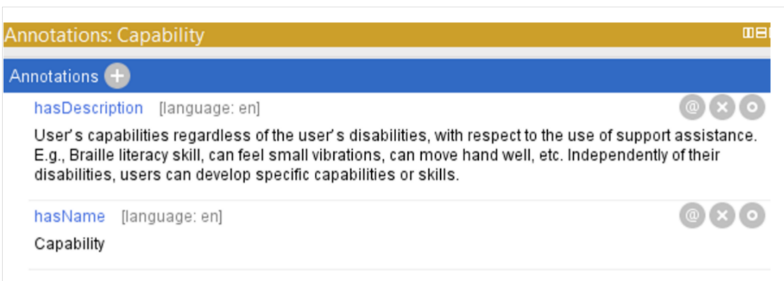


Figure 4.19 Capability class annotations, name and description

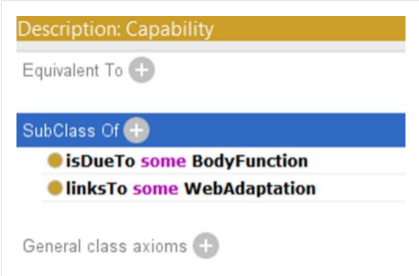


Figure 4.20 Capability class relations with other classes

WebAdaptation class

The *WebAdaptation* class was renamed from the *Support Assistance* Class of the ACCESIBILITIC ontology. Web adaptations are the user interface elements that need to be adapted to improve the web experience and web accessibility for people on the autism spectrum (Figure 4.21). A web adaptation is intended for some disability, as far as this research is concerned, for users on the autism spectrum, and some web adaptations require capabilities from the user. These conditions are expressed as relations with the *Disability* and *Capability* classes, and presented in Figure 4.22.

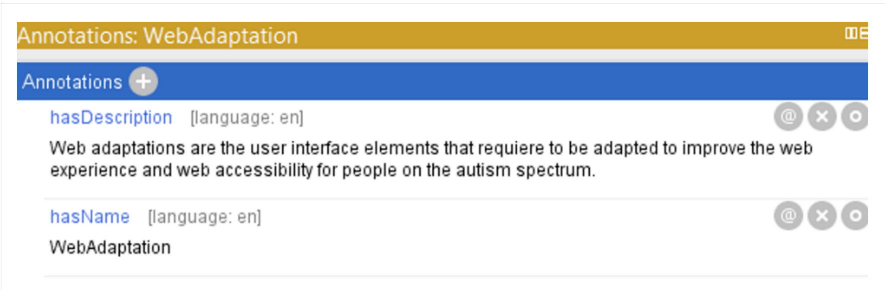


Figure 4.21 WebAdaptation class annotations, name and description

Figure 4.22 WebAdaptation class related with other classes

The autism profile (AutismProfile) class indicates the user interface elements that need to be adapted to facilitate web accessibility for autistic users. The *WebAdaptation* class contains the web design guidelines (webDesignGuidelines) presented in Chapter 3 of this thesis; they were created as ontology individuals as presented in Figure 4.23.

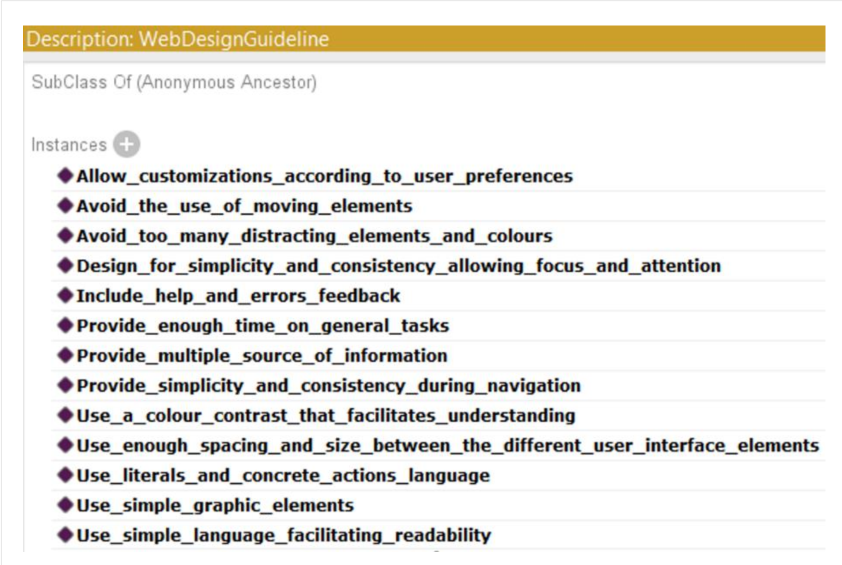


Figure 4.23 Web design guidelines created as individuals from the WebDesignGuideline class

Some of the web design guidelines are related to specific user interface elements as presented in the ontology requirements specification, and they are represented as subclasses and corresponding individuals as presented in Figure 4.24 and Figure 4.25.

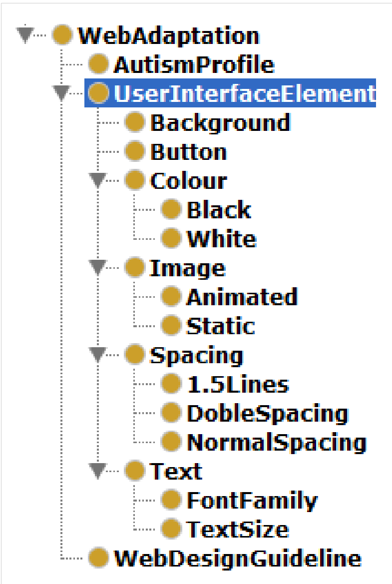


Figure 4.24 WebAdaptation subclasses – UserInterfaceElement

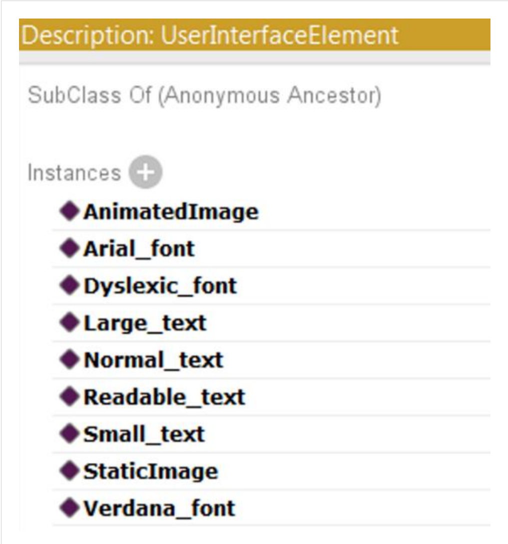


Figure 4.25 Individuals of the UserInterfaceElement class

4.4.4.2 Object properties

The object properties used in webDesignASD are presented in Figure 4.26. They are the properties that link all classes and most of them were taken from the ACCESIBILITIC ontology. Detailed information about each object property is presented in the documentation of the ontology in Appendix D.

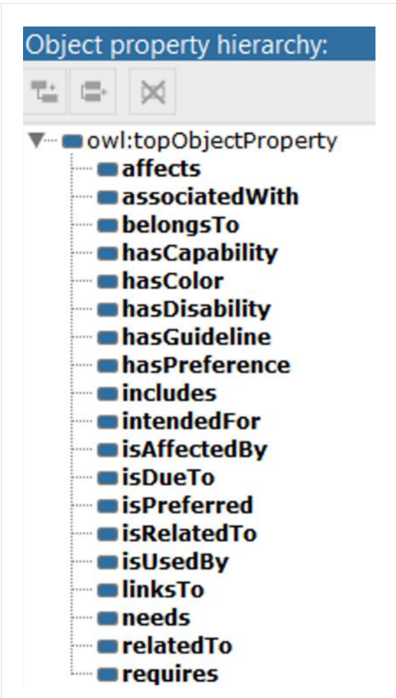


Figure 4.26 Object properties of webDesignASD ontology

Data properties

The data properties used in the webDesignASD ontology are presented in Figure 4.27. Detailed information about each data property is presented in the documentation of the webDesignOntology in Appendix D.

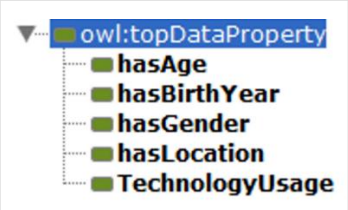
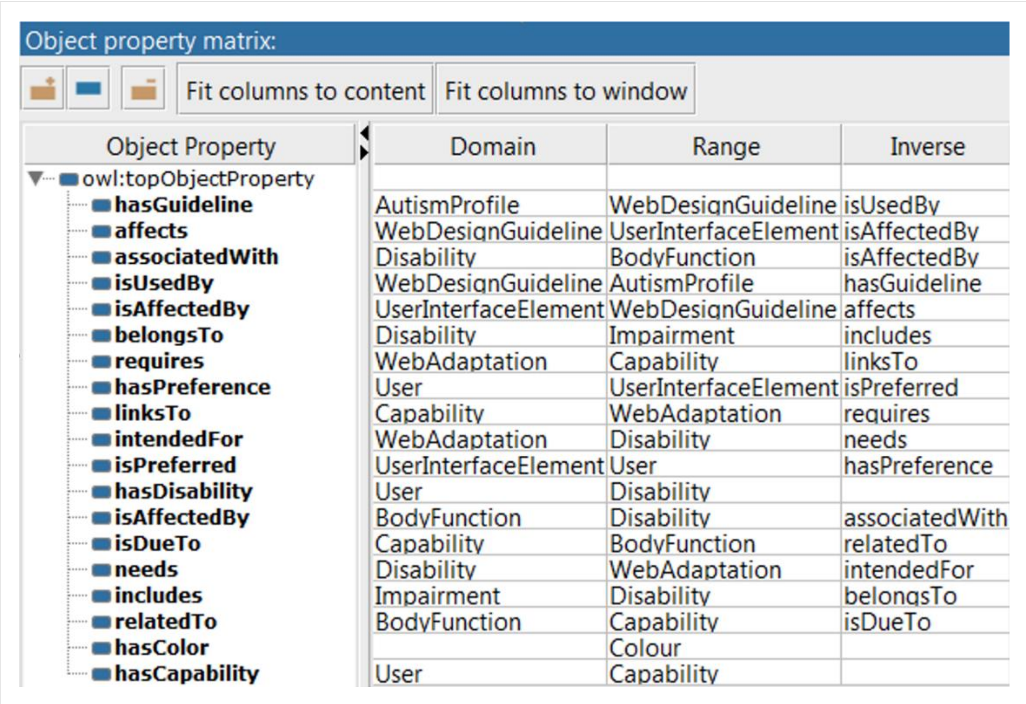


Figure 4.27 Data properties of webDesignASD ontology

The matrix view of the object properties of the webDesignASD ontology is presented in Figure 4.28.



Object Property	Domain	Range	Inverse
owl:topObjectProperty			
hasGuideline	AutismProfile	WebDesignGuideline	isUsedBy
affects	WebDesignGuideline	UserInterfaceElement	isAffectedBy
associatedWith	Disability	BodyFunction	isAffectedBy
isUsedBy	WebDesignGuideline	AutismProfile	hasGuideline
isAffectedBy	UserInterfaceElement	WebDesignGuideline	affects
belongsTo	Disability	Impairment	includes
requires	WebAdaptation	Capability	linksTo
hasPreference	User	UserInterfaceElement	isPreferred
linksTo	Capability	WebAdaptation	requires
intendedFor	WebAdaptation	Disability	needs
isPreferred	UserInterfaceElement	User	hasPreference
hasDisability	User	Disability	
isAffectedBy	BodyFunction	Disability	associatedWith
isDueTo	Capability	BodyFunction	relatedTo
needs	Disability	WebAdaptation	intendedFor
includes	Impairment	Disability	belongsTo
relatedTo	BodyFunction	Capability	isDueTo
hasColor		Colour	
hasCapability	User	Capability	

Figure 4.28 Object properties matrix, webDesignASD ontology

Web design guidelines

The web design guidelines listed in Chapter 3 are created as individuals corresponding to the WebDesigGuideline class (Figure 4.29). Some web design guidelines affect specific user interface elements and these are detailed in the documentation of the webDesignOntology in Appendix D.

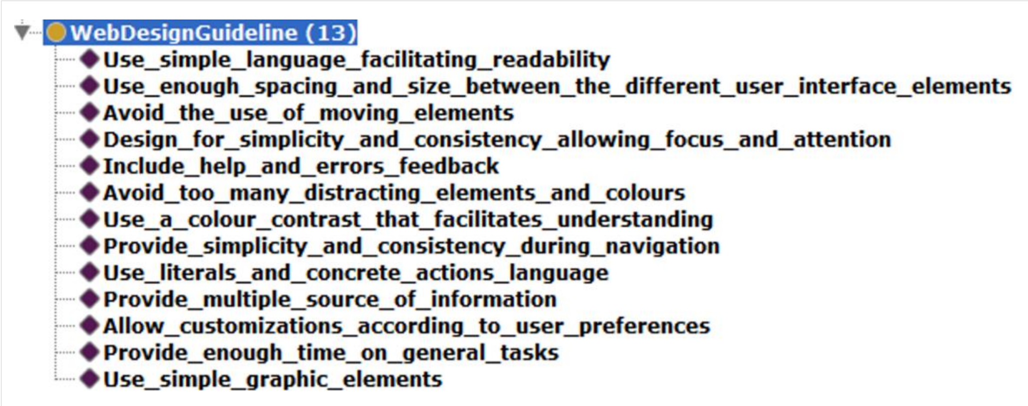


Figure 4.29 Web design guidelines as ontology individuals

Individuals

The user profile is registered in the ontology using the corresponding ontology individuals (Figure 4.30). Detailed information about each ontology individual is presented in the documentation of the webDesignOntology in Appendix D.

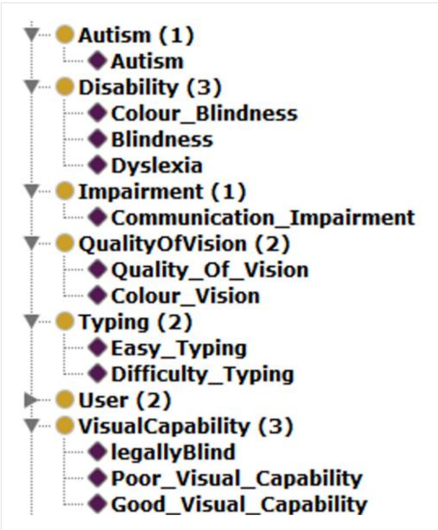


Figure 4.30 webDesignASD ontology individuals representing the user profile

4.4.5 Ontology implementation

The webDesignASD ontology was finalised and it is published following the link https://github.com/clau1228/PhD and it is presented in Appendix D.

The webDesignASD ontology answers the competency questions outlined in the following section:

1. **What is a suitable font type and size for an autistic and dyslexic user who needs glasses to operate a computer?**

To answer this question, User01 was selected and his property assertions are presented in Figure 4.31. His profile says that, as a disability, he has autism (Autism), and as capability he has a good visual capability (Good_Visual_Capability). He prefers to have white background (White_background), black font (Black_font), small size font (Small_font), and type of font Arial (Arial_font). And the axiom is presented in Table 4.5.

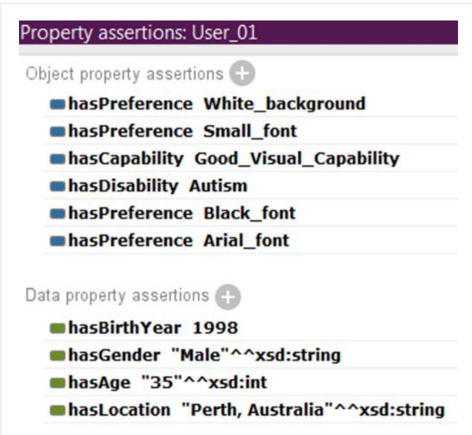


Figure 4.31 Property assertions User01

Table 4.5 Axiom:User01_WebAdaptation

Axiom name	**User01_WebAdaptation**
Description	Explains the web adaptation that the user requires according to his disabilities, capabilities and preferences.
Expression	∀ (?X,?Y,?Z) [WebAdaptation](?X)and[Disability](?Y)and[Capability](?Z) →[intendedFor](?X,?Y)and[intendedFor](?Y,“Autism”) And [requires](?X,?Z)and[requires](?Z,”Good_Visual_Capability”)
Concepts	WebAdaptation, Disability, Capability
Binary relation	intendedFor, requires
Variables	?X,?Y,?Z

2. **Which font and background colours are suitable for an autistic user who does not need glasses to operate a computer?**

This question can be answered if an axiom is created when a user has the autism disability and has good visual capability. The axiom is presented in Table 4.6.

Table 4.6 Web profile for an autistic user with good vision

Axiom name	Autistic user with good vision
Description	Explains the web adaptation that an autistic user requires if he has a god visual capability.
Expression	∀ (?X,?Y,?Z) [WebAdaptation](?X)and[Disability](?Y)and[Capability](?Z) →[intendedFor](?X,?Y)and[requires](?Z,"Good_Visual_Capability")
Concepts	WebAdaptation, Disability, Capability
Binary relation	intendedFor, requires
Variables	?X,?Y,?Z

3. **Are moving elements such as files with gif extensions and blinking images suitable for autistic users on a web interface?**

To answer this question and axiom related to the user interface elements that an autistic user needs to have would present the required results. The axiom is presented in Table 4.7.

Table 4.7 Image type suggested for autistic users

Axiom name	Image type suggested for autistic users
Description	Explains the type of image that a web adaptation requires for an autistic user
Expression	∀ (?Y,?Z) [Image](?Y)and[Disability](?Z) →[intendedFor](?Y,?Z)and[intendedFor](?Y,"Autism")
Concepts	UserInterfaceElement, Disability
Binary relation	intendedFor,
Variables	?Y,?Z

4.5 Discussion and conclusions

When compared with traditional websites, semantic web portals have the benefit of reusing and sharing of knowledge. This chapter presented the design of a semantic web portal aiming to facilitate web accessibility to autistic users.

This framework included the creation of a new ontology called the webDesignASD ontology, in which elements for related ontologies were integrated. This ontology can be used for any other project or by any developer aiming to reuse or expand the knowledge about the autistic profile when navigating web interfaces. As each individual has preferences, they were included in the specification of this ontology. If a website is interested to integrate this ontology as part of their design, the users' preferences should be mapped to the ontology and they should be replicated in the final presentation of the website.

The original and novel contribution of knowledge in this thesis is demonstrated in the reutilisation and expansion of ontologies that have shown that autistic users require web interface adaptations to improve their user experience. With the creation of the web design guidelines for autistic users expressed as ontologies, many web developers and content creators can access centralised and proven documentation about the web requirements tailored for web users with different disabilities, capabilities and preferences.

There were several ontologies that the source code could not be located given copyright restrictions or limited documentation where they were initially published, so the linking URL was not possible but, in the comments, and documentation of the ontology was recorded which publication or study proposed said ontology part. As ontologies are a live computable file, the author expects that when more ontologies related to web accessibility for autistic users become available, they will be integrated into this newly created ontology.

Chapter 5 presents the software implementation and evaluation of the web design framework presented in this chapter.

Chapter 5 Software implementation and evaluation: A case study of a transport-planning website

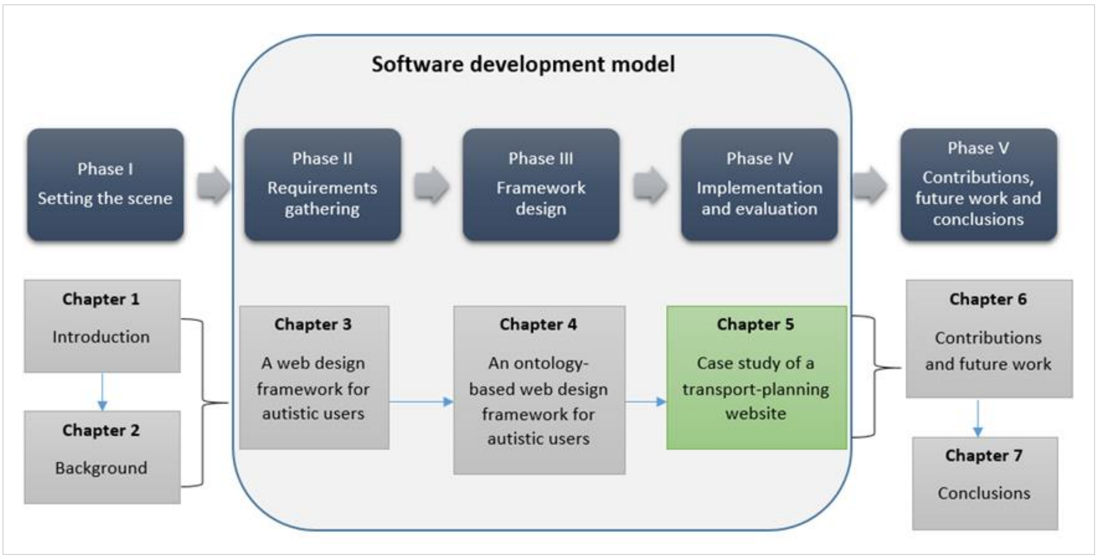


Figure 5.1 Chapter 5 in the context of the thesis structure

After obtaining the requirements to create accessible desktop websites for autistic users (Chapter 3), and presenting a design based on semantic web technologies (Chapter 4), Phase IV comprises the implementation and evaluation which are presented in this chapter (Figure 5.1) through the application of a transport-planning website called Adaptable-maps.

There can be multiple barriers for autistic people accessing transport (Deka et al., 2016; Cecelia Feeley, 2014; Lubin & Feeley, 2016). Current transport mobile applications and websites related to transport-planning are not designed to take into consideration the different needs and limitations of all users, and therefore fail to consider usability and accessibility for everyone (Medina et al., 2015). The piloting and evaluation of the Adaptable-maps website presented in this chapter, validated the complexities and challenges experienced by autistic users when accessing some current transport-planning websites, and showed how a personalised website, based on their needs and preferences, can improve their interaction and level of functioning.

This chapter is divided in four parts: an explanation of the case study of transport-planning websites, the Adaptable-maps website implementation, a description of the evaluation method, and finally, the presentation of the results.

5.1 Case study: Web interface design for transport-planning websites

With the aim to implement and evaluate some of the findings obtained through this thesis, a website related to transport planning was used as a case study.

This case study was selected because transportation is important for every individual in order to achieve independence, to socialise, participate in education, employment, health services and to be included in society (Lubin & Feeley, 2016). The transportation process can be a complex practice given the different modes of transportation (e.g. bus, train, car, bicycle or as a pedestrian), the different costs associated with the different services, the safety conditions, and the social rules when dealing with the general public (Loprest & Maag, 2001). These are some factors to be considered in making one's transportation choice.

The cognitive profile of autistic individuals can contribute to difficulties using transportations, these may include but are not limited to, communication limitations, difficulties using a variety of transport modes safely, having fixed public transport routes, difficulties in obtaining a driver's license and the need to rely on caregivers (M. Falkmer et al., 2015; Cecilia Feeley & McGackin, 2015). For many autistic individuals, visual perceptual problems and poor location awareness, in addition to a lack of understanding of the various transit systems, limits their capacity to travel independently (Cecilia Feeley, 2010). Hence, there are multiple barriers for autistic people accessing transportation and this has negative consequences in medical care, education, employment and other life-enhancing activities (Deka, Feeley, & Lubin, 2016; Cecilia Feeley, 2010; Cecilia Feeley & McGackin, 2015; Lubin & Feeley, 2016) even as it is one of the most important activities for any individual to gain independence (M. Falkmer et al., 2015; Cecilia Feeley & McGackin, 2015).

In conclusion, this case study was needed as the current transport-planning applications and websites lack accessibility for everyone (Medina, Cagnin, & Paiva, 2015). It is required to take into consideration the different needs and preferences of autistic users and therefore to consider usability and accessibility for everyone. Then, the Adaptable-maps website was implemented and evaluated. In the next section, the implementation of the website is explained.

5.2 Adaptable-maps website implementation

Any website requires three basic components to operate: a client, a server and a database (Figure 5.2), also known as "presentation – logic – data" architecture. The top-most level is the client side from where end-users, using different devices (e.g., computers, tablets or mobile phones), navigate the Web. Software that is needed to load and operate the website is hosted on a web server which process commands, makes logical decisions and evaluations, and performs calculations. The web server processes data between the client and database, and needs communication with the database where information is stored. The information is then passed back to the logic processor, and then eventually back to the end-user.

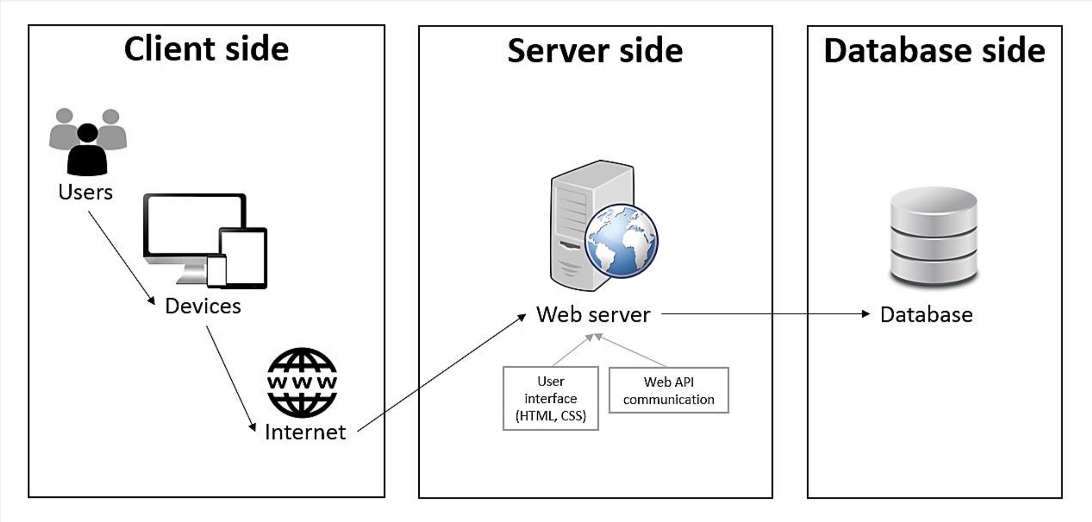


Figure 5.2 Website architecture using databases

In a website using ontologies, the architecture needs to include more elements on the server to provide the reasoning needed for inferencing and linking data. Figure 5.3 shows the three different sides of the architecture (Client, server and data) based on the Jena Framework (W3C, 2018a).

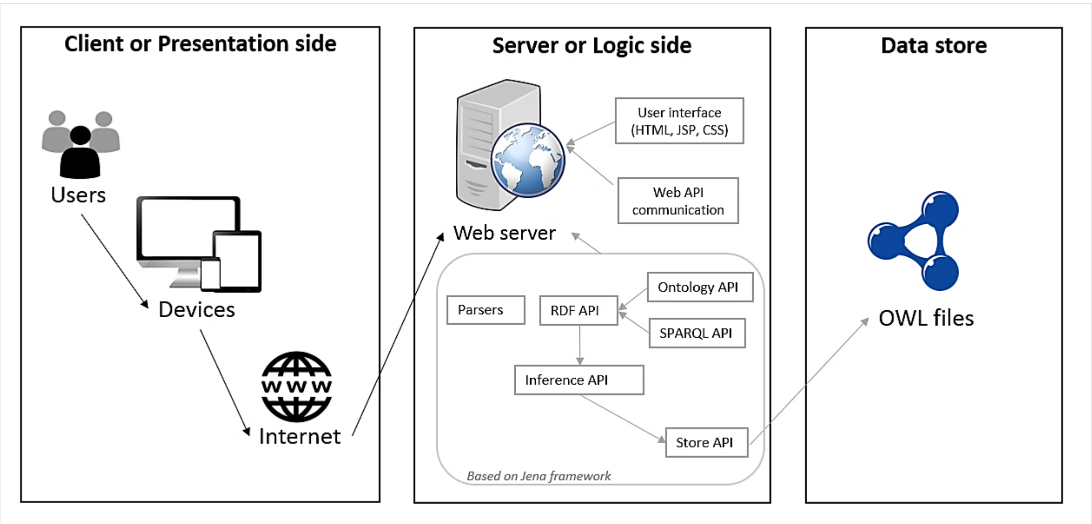


Figure 5.3 Website architecture using semantic web and based on the Jena Framework

There are several programming languages, frameworks and techniques capable of implementing this software development. It is beyond the scope of this research to explore the architecture and software implementation of ontology-based websites, hence no specific programming language, framework, or software architecture is endorsed in this thesis.

The presentation side of the website is most relevant to this thesis, so this is where the analysis and discussion will focus. The home page of the Adaptable-maps website was designed following the web design guidelines found and listed in Chapter 3. The Adaptable-maps home page design is presented in Figure 5.4. It comprises a simple and clean main menu located in the top of the page and aligned to the left-hand side.

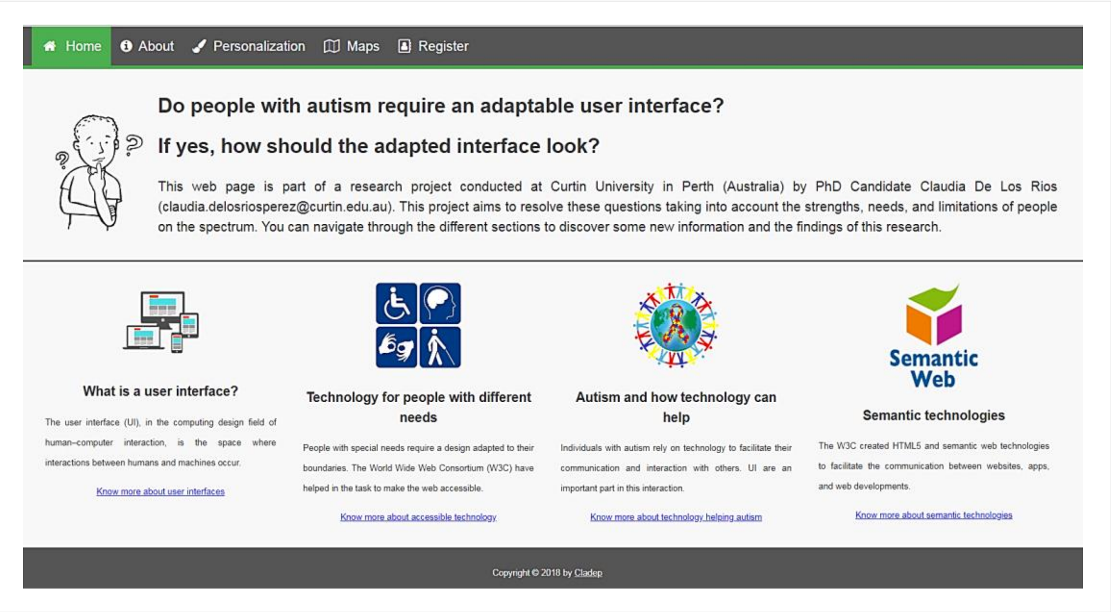


Figure 5.4 Adaptable-maps website – Home page

The main content and website objective are located under the main menu, and some side information is located under it. There are no moving elements and the colour contrast between the background and the font support readability and understanding. Icons, headings and links are easily located. The Adaptable-maps website had the following functionalities:

- On the Register page, the user completes the sign-up form and fills in their profile, and the system stores this information and provides the best user interface profile based on their visual conditions and preferences. The Sign-up webpage design is presented in Figure 5.5. The Study ID was a consecutive number used in the study.

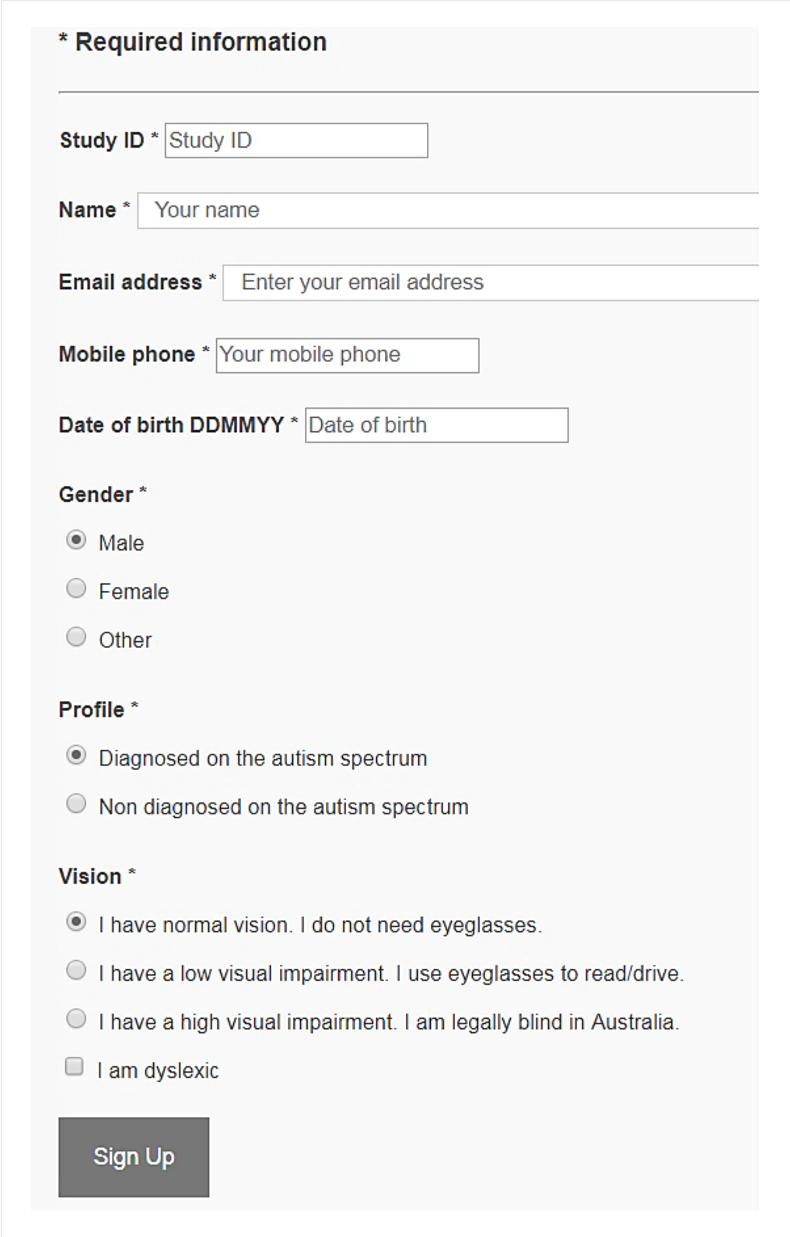


Figure 5.5 Sign-up form in Adaptable-maps website

- On the Personalisation page, the user can personalise the website according to their preferences of font-type, font-colour, font-size, font-size, line spacing and button design. The initial preferences are filled according to the user's profile. For example, if the user indicated that they have normal vision, the font type is auto-selected as Arial, medium size, with 1.0 line spacing. However, if the user selected in their profile that they have low vision and are dyslexic, then the auto-selected options will be font-type dyslexic and large size. The user can always change their preferences and see how the combinations of options look like by referring to the box in the same webpage. For example, Figure 5.6 shows what the user would see if they selected the

Dyslexic font in black colour and small size with a white background and line spacing of 1.0.

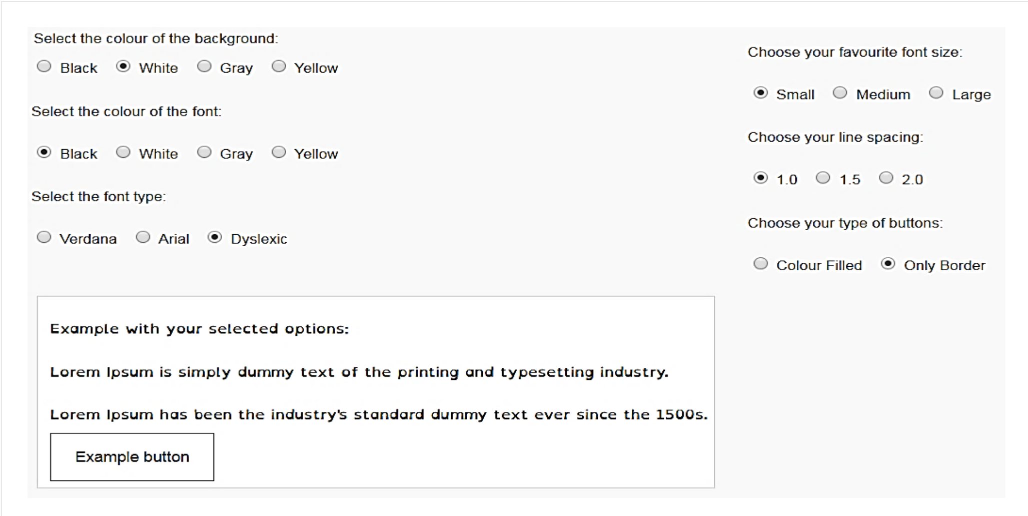


Figure 5.6 Personalisation options in Adaptable-maps website

- On the Maps page, the icons indicating the mode of transportation had labels according to their functionalities. Driving has a car icon, Public transport has a train icon, Cycling has a bicycle icon and Walking has a Walking-person icon. The icons showing modes of transportation are presented in Figure 5.7.

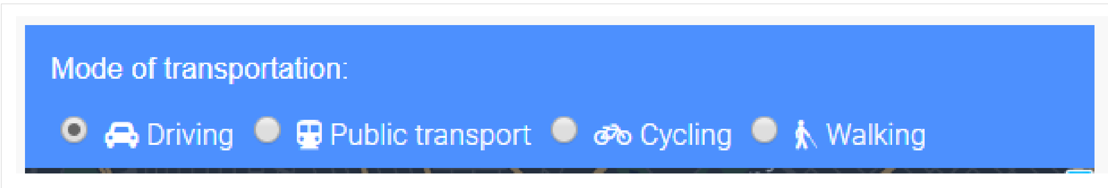


Figure 5.7 Mode of transportation menu in the Adaptable-maps website

- The user could manipulate the map to select between different colour styles. The “Styled map” style was created to generate more contrast between the main roads and the other elements in the map (Figure 5.8). The “Satellite” style presents the map in a satellite view (Figure 5.9), and the “Map” view presents the traditional view (Figure 5.10). The user could remove the labels on the map, could see the map in full screen mode, or zoom-in/zoom-out. The web mapping service used to create this map was the free Google maps Platform Documentation API framework (Google, 2019).

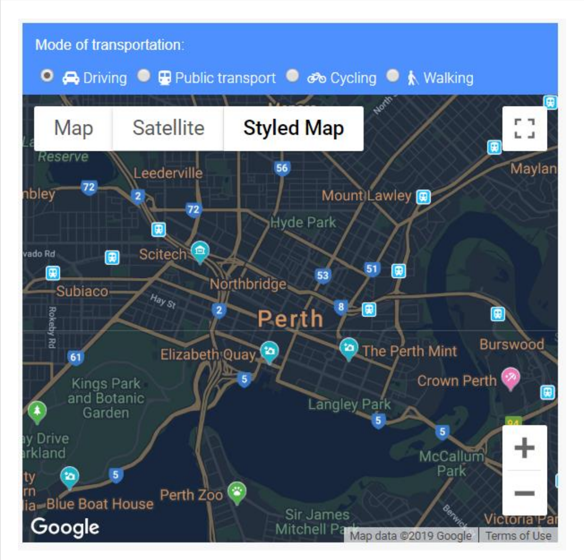


Figure 5.8 Adaptable-maps website – Styled map

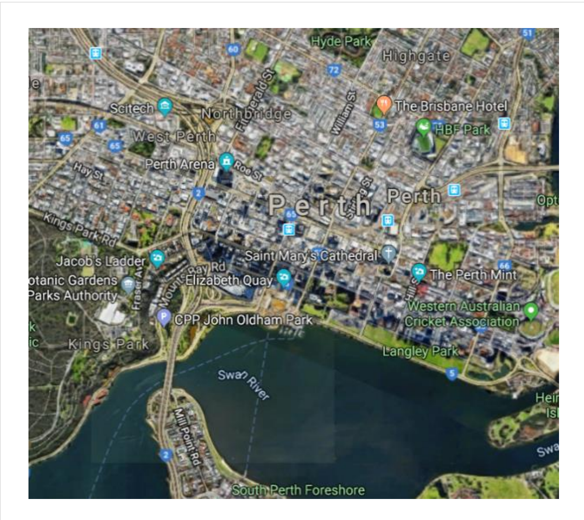


Figure 5.9 Adaptable-maps website – Satellite map

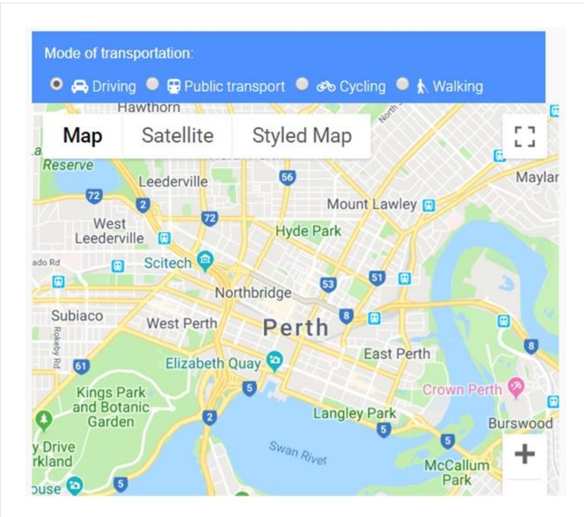


Figure 5.10 Adaptable-maps website – traditional-view map style

- On the Maps page, the user could search for instructions for how to get from a starting point to an end point. The labels Start and End were suggested during the focus group described in Chapter 3 and its design is presented in Figure 5.11.

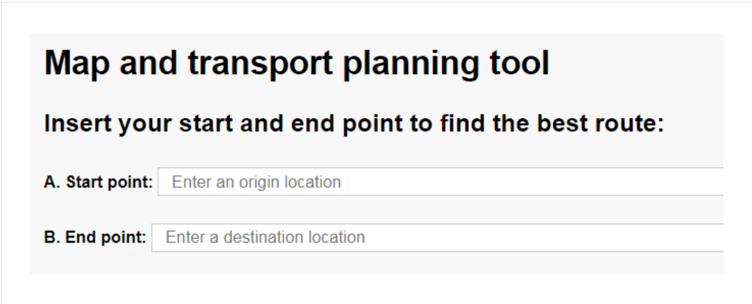


Figure 5.11 Adaptable-maps website – Start and End points to find a route

5.3 Adaptable-maps evaluation method

The evaluation method is explained through the following sections: design, materials, participants, apparatus, procedure, and data and analyses.

5.3.1 Design

A group of 25 autistic adults participated in a single session in which a survey and an evaluation using an eye-tracking were performed. The session was conducted at Curtin University in Perth, Western Australia, in the eye-tracking laboratory located in building 603.

Each participant was offered a token of appreciation for their participation in the study in the form of a gift card and they were required to sign a consent form. Appendix A shows the human ethics approval for this research, the participant information statement form and the participant's consent form.

5.3.2 Materials

5.3.2.1 Survey

The survey was divided into three sections: the first one looked at general perceptions about transportation, the second was used during the experiment, and the third and last section was used at the end of the experiment. The survey is presented in Appendix E.

The survey was elaborated using Qualtrics Software (Qualtrics LLC, 2019) which allows online surveys to be created using different types of questions and a customisable visual presentation. For this survey, each question was enumerated and presented on a single page, and the survey progress was presented at the bottom of the page.

5.3.2.2 Eye-tracking

Eye tracking is a process by which an eye-tracking device measures the point of gaze of an eye (gaze fixation) and the motion of an eye (saccade) relative to the head and a computer screen, and gaze fixations and revisits (go-back fixations to a previously fixated object) have been widely used as measures of cognitive effort by taking into account their durations and the places where they occur (Duchowski, 2017). Eye tracking provides valuable data for researchers seeking to understand the user experience of websites to improve web usability because it collects data that the participant themselves could not give, as it is an unconscious process that evaluates the visual scanning or gaze behavioural patterns of participants.

Relevant to this thesis, a previous study found that there is strong evidence that autistic users demonstrate significantly different eye movement when searching on the Web compared to non-autistic users (Eraslan et al., 2018). Autistic users tended to look more at irrelevant elements and had longer scanpaths. Their fixations' durations tended to be shorter and they had more transitions between the elements of the web pages (Eraslan et al., 2018). Finally, the researchers concluded that autistic users tend to employ different information searching strategies when processing web pages, and that the content of the webpages needs to be improved to better accommodate these differences.

5.3.3 Participants

The participants in the evaluation study were 25 adults diagnosed with autism or Asperger's syndrome, 19 male (76%) and 6 females (24%). The youngest participant was 19 years, the oldest was 42 years old, and the mean age of the total sample was 23 years with a standard deviation of 5.6 years.

The main recruitment channel was the Curtin Specialist Mentoring Program (CSMP) at Curtin University (Perth – Western Australia) which is a mentoring program specially designed to support undergraduate students on the autism spectrum, or those with similar conditions, during their studies. An email and brochure about the study were circulated to the CSMP mentees and they contacted the researcher to validate for inclusion criteria. The study was also shared with all members of the Curtin Autism Research Group (CARG) at

Curtin University. All members of the CSMP and CARG group were asked to share this research information with colleagues and friends.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. This research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number HRE2017-0621.

In terms of inclusion and exclusion criteria, to be able to participate in this study, all participants were required to be adults with an autism or Asperger's diagnosis. They needed to be regular users of the Web and to not be legally blind according to the Australian criteria.

5.3.4 Apparatus

The device used for recording the gaze of the participants during task performance was a SMI remote eye-tracker (60Hz sampling rate) (SMI, 2019) with a 19" LCD monitor located approximately 65 centimetres from the user's face. No equipment was attached to the participant. The device was calibrated at the start of every recording using a 4-point calibration procedure.

5.3.5 Procedure

All participants performed the experiment in the eye-tracking laboratory with the guidance of one researcher, each participant in a single session. The procedure is presented in Figure 5.12. The initial setting consisted of providing a study number to each participant in order to complete their consent form for participating in the research study (this consent form is presented as part of Appendix A), and to complete their profile into the system using a web form where demographic information was collected. The demographic information corresponded mainly to age, gender, autism diagnosis and visual condition.

Next, the participant was asked to answer some questions about general perceptions about transportation and some transport-planning preferences such as which device was preferred to plan a journey, which websites were the most used and how frequently they were used. After the initial survey was completed, the website's evaluation started using the remote eye-tracker, followed by the final survey were the transport-planning websites were evaluated and general perceptions about web accessibility were collected.

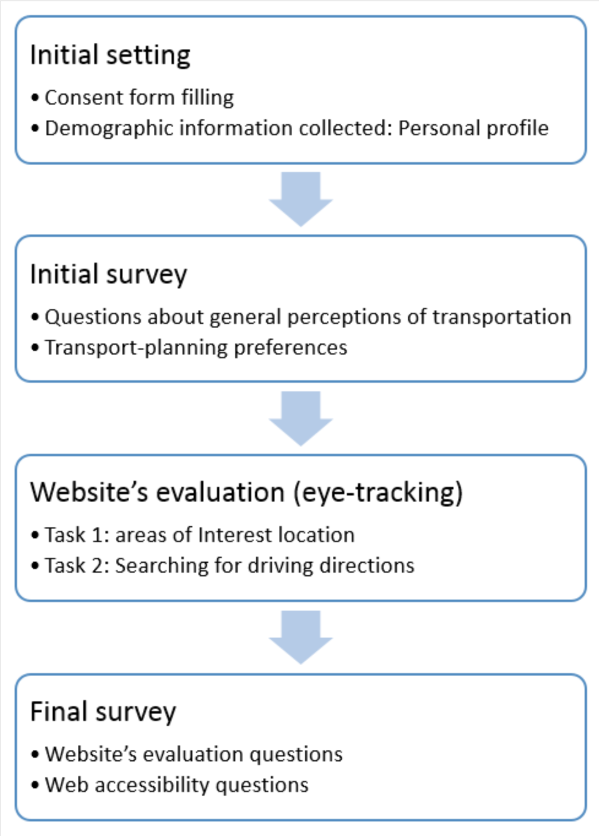


Figure 5.12 Website's evaluation procedure

The website's evaluation using the remote eye-tracker consisted on the following tasks:

Task 1: Searching areas of interest in four websites using an eye-tracker

The participants were instructed that the eye-tracking activity was about to start and the apparatus needed to be calibrated. The calibration is needed to adapt the eye-tracking software to the subject's eye characteristics, and consisted on presenting to the participant a number of targets in known screen locations, the participant needs to fixate the presented targets while the position of the participant's gaze is registered by the eye-tracking software. To get correct measurement results, it is vital to execute calibration before presenting any stimuli to the participant.

When the calibration was completed, the first eye-tracking activity started with screen shots of the websites related to transport-planning and the user was asked to locate two Areas of Interest in each website, with the following prompts:

- Can you locate where are to zoom in/out in the website?
- Can you locate the search box to start looking for places?

The Google maps website screenshot used for this task is shown in Figure 5.13, the Bing Maps website screenshot is presented in Figure 5.14, the Waze website screenshot is presented in Figure 5.15, and the Adaptable-maps website screenshot is shown in Figure 5.16. The task could be completed without using a mouse or a keyboard, and therefore the participants were asked to use only a verbal report to indicate the results of the tasks. After the four screenshots were presented and the corresponding questions were answered, Task 1 was considered complete.

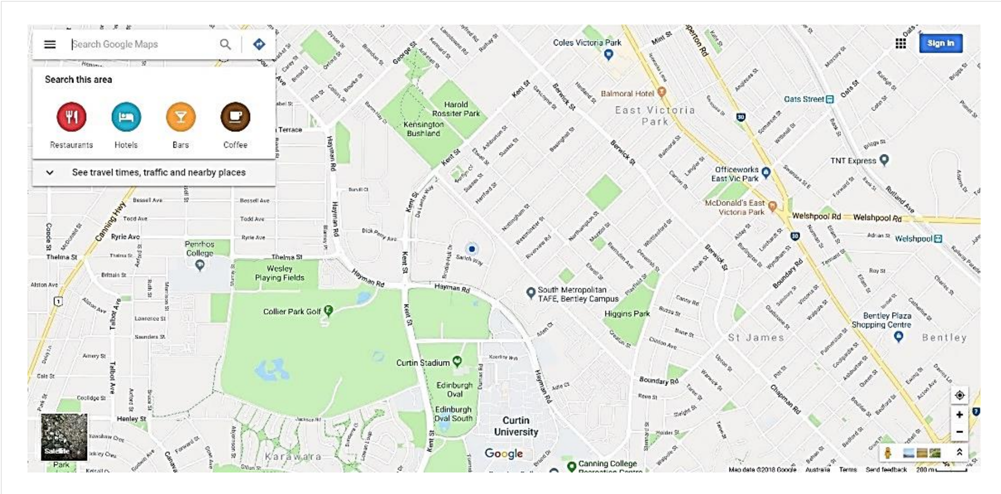


Figure 5.13 Google maps website home page screenshot

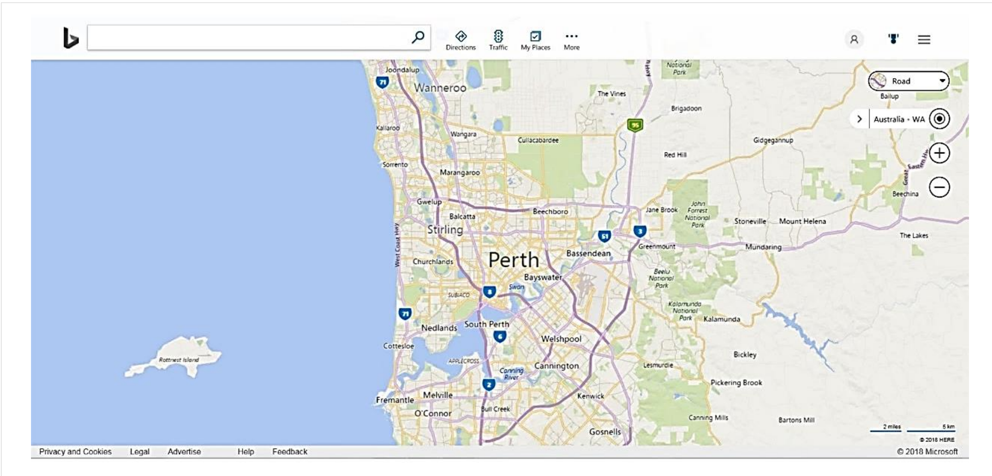


Figure 5.14 Bing maps website home page screenshot

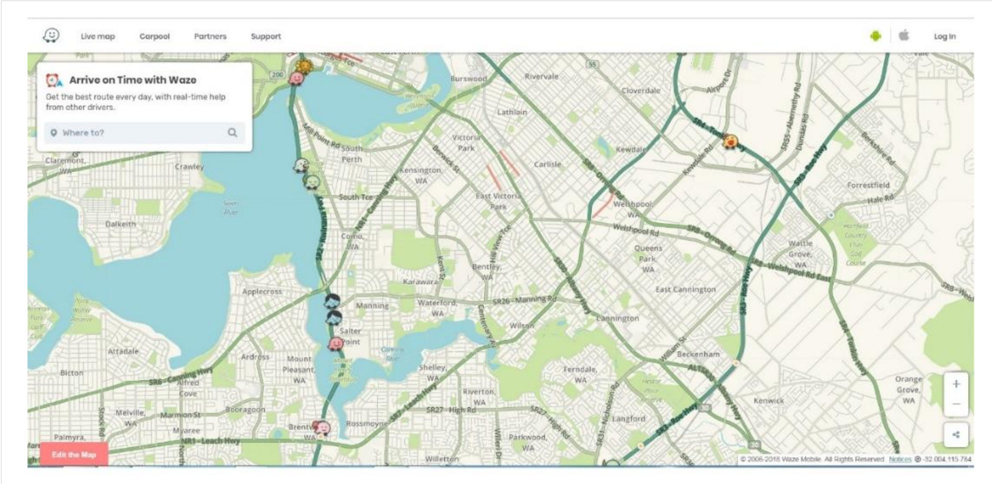


Figure 5.15 Waze website home page screenshot

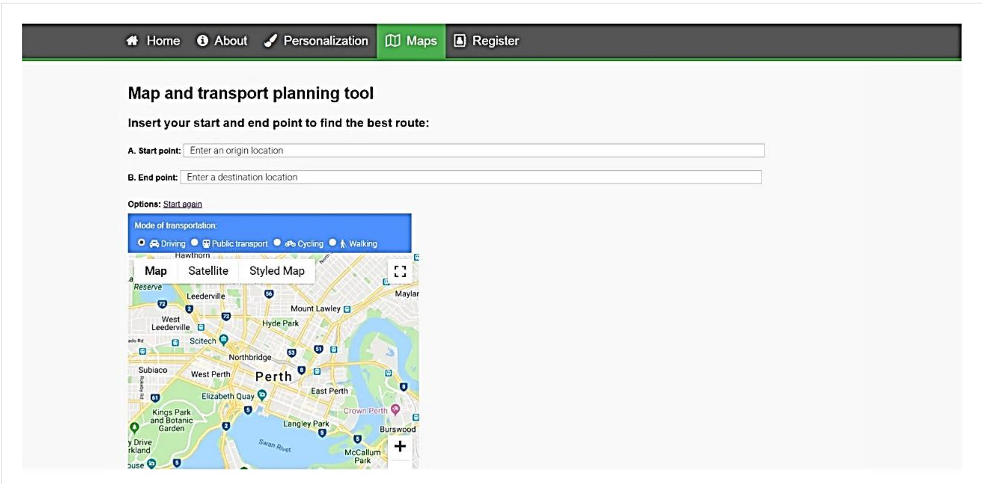


Figure 5.16 Adaptable-maps website home page screenshot

Task 2: Searching for driving directions

After Task 1 was completed, the eye-tracking evaluation continue with a videorecording of the screen where an Internet browser was open on the home page of one of the four websites: Google maps, Bing maps, Waze or Adaptable-maps.

The initial six participants, out of the total group of 25, evaluated three websites: Bing Maps, Waze maps and the Adaptable-maps website. The following 19 participants evaluated four websites: Bing Maps, Waze maps, Google maps and Adaptable-maps. This decision was made because preliminary data analysis revealed that Google maps was the existing website that was most frequently used and there was a need to discover if the evaluation had any different results if it was included. The order of the websites to be evaluated was randomised to avoid the familiarity factor from the second to the last website.

Tasks 2.A and 2.B required participants to answer the following questions for each website while the time duration they spent doing it was recorded:

Task 2.A: Can you find the directions from Perth Station to Curtin University bus Station? How long does it take by car? How long does it take by public transport?

Task 2.B: Can you find directions to the Opera House from the Hilton Hotel, George St. in Sydney, Australia? How long does it take by car? How long does it take by public transport?

The participants were randomly instructed to complete Task 2.A, Task 2.B, or in some cases they were instructed to do both tasks because it was relevant for comparison if the duration to complete both tasks sequentially were different. Task 2.A asked them to get instructions to a familiar place for them because all participants live in Perth – Australia, and Task 2.B, to an unfamiliar place.

After the tasks were completed in each website, the participant was asked to complete a survey about the website and to score the website on a scale ranging from 0 to 10, with 10 being the highest and best score for a website. Task 2 was considered complete when the task and individual score were completed for all four transport-planning websites. After Task 2 was completed, the eye-tracking recording was stopped.

After Task 2 was completed, the user was instructed to complete the final survey providing feedback about the preferred website among all transport-planning websites evaluated, and the participants were also asked about their general attitude towards web accessibility.

When the survey was finished, the participant received a token of appreciation and the experiment was completed.

5.3.6 Data and analyses

The data relevant to this research was collected from the online survey and the website's evaluation using an eye-tracking gaze data.

Survey

The survey is presented in Appendix E. The first section asked for general perceptions about transportation and it included eight questions such as frequency of use of different transport-planning websites, preferred device to plan a journey, preferred transport-planning websites, and use of intelligent personal assistant. The second part of the survey was used during the website's evaluation and it looked to know user's opinion about the user experience after using each individual website. The last part of the survey corresponded to questions comparing the evaluated websites and asked for general feedback about transport-planning websites and web accessibility. At the end of the evaluation, the Qualtrics Software used to manage the survey, generated a Microsoft Excel file containing all responses and the qualitative data was analysed using the NVivo software (QSR International Pty Ltd, 2019), version 12.

Website's evaluation

The website's evaluation included two tasks. The first one was to locate two areas of interest in each website (the zoom in and out buttons and the search box), and then the participants were asked to find driving directions in each website. Gaze data and time to complete the tasks were recorded in both cases. The gaze data was stored and analysed using the behavioural and gaze analysis SMI BeGaze eye-tracking software which is fully integrated with the study design and recording software SMI Experiment Centre. Studies that investigate web accessibility have explored eye-tracking gaze data such as fixations, saccades, scanpaths (sequence of eye movements made by an observer) (Coutrot, Hsiao, & Chan, 2018), and heat maps, which are three-dimensional objects (x, y, fixation density) representing the spatial distribution of eye positions at a given time. The relevant areas on each website are organised into Areas of Interest (AOIs), which are the visual elements or regions in which the raw eye-tracking data is analysed (Duchowski, 2017). By using this method during a usability test, it is possible to analyse what the user is looking at and for how long, identifying what features in a website capture the most interest.

The variables analysed in each website were as follow and they are explained following the theory presented in these publications (Coutrot et al., 2018; Duchowski, 2017; Menges et al., 2018):

- Number of fixations in each area of interest: more fixations indicate more relevant information.
- Duration of fixations: longer fixations indicate difficulty in extracting info.
- Number of fixations overall: more fixations indicate a less efficient search.
- Number of saccades: a high number of saccades indicate more searching
- Spatial density: smaller density indicates more direct search

The variables to be analysed between websites are:

- Number of fixations on different websites
- Fixations on Areas of Interest AOI on different websites
- Duration to complete the task to find driving directions. Each participant duration and average duration from each website from all users.
- Did the user correctly complete the task?

Data collected in SMI BeGaze was exported and analysed using Microsoft Excel and the statistical software IBM SPSS Statistics. SMI BeGaze also generated relevant maps for this study such as scan path, focus map, and heat map. Each of them will be explained in the context of the results.

5.4 Results

5.4.1 Survey about general transport preferences

The first section of the survey looked to find out general perceptions about transportation. Responses from 25 adults on the autism spectrum were collected with the following results:

The main mode of transportation among the participants was “public transport” (64%), followed by “driving” (12%), then “bicycle” and “rely on someone else to be transported” with same percentage (8%), and lastly “any other way of transportation” (4%).

The favourite form of transportation was public transport voted by 32% of participants, followed by driving a particular vehicle 24%. The same percentage (16%) was recorded for “rely on someone else to be transported” and “to walk” followed by bicycle 8%, and any other form of transportation 4%.

The most unsafe form of transportation was considered to be to driving a particular vehicle (40%), riding a bicycle (24%), relying on someone else to be transported (20%), and lastly public transport and walking, both with 8%.

The most used device for planning their transportation was mobile phone (64%), followed by computer (32%), and any other way (4%). The first tool to plan a commute to an unknown place was a public transport app (52%), followed by a transport-planning website (16%). Lastly, “printed maps”, “asking someone for advice”, “following signal and find my way”, and “any other” each received 8% as the preference.

“Intelligent personal assistant” was not used by 76% of participants, “Google assistance” was used by 16%, and “Siri” by Apple was used by 4% of participants. The remaining 4% declared that they did not know what an intelligent personal assistant was.

The survey looked to find out the frequency of use of current transport-planning websites and printed maps. Google maps was selected as being used every day by 28% of participants, followed by the local transport-planning website (Transperth, in Perth, Western Australia) with 12%, followed by Apple Maps with 8%, only 4% use Bing maps twice a month and Waze had never been used by any of the participants. Complete details of frequencies of use are presented in Table 5.1 and Figure 5.17.

Table 5.1 Frequency of use of transport-planning websites and printed maps

	Always (Every day)	**Most of the time (2-3 times per week)**	**About half the time (Once a week)**	**Sometimes (Twice a month)**	**Never**
How often do you use Google maps	28.0%	8.0%	16.0%	40.0%	8.0%
How often do you use Apple maps	8.0%	0.0%	4.0%	8.0%	80.0%
How often do you use Bing maps	0.0%	0.0%	0.0%	4.0%	96.0%
How often do you use Waze	0.0%	0.0%	0.0%	0.0%	100.0%
How often do you use Local website/app (E.g. Transperth)	12.0%	28.0%	12.0%	32.0%	16.0%
How often do you use Printed map	4.0%	8.0%	4.0%	32.0%	52.0%

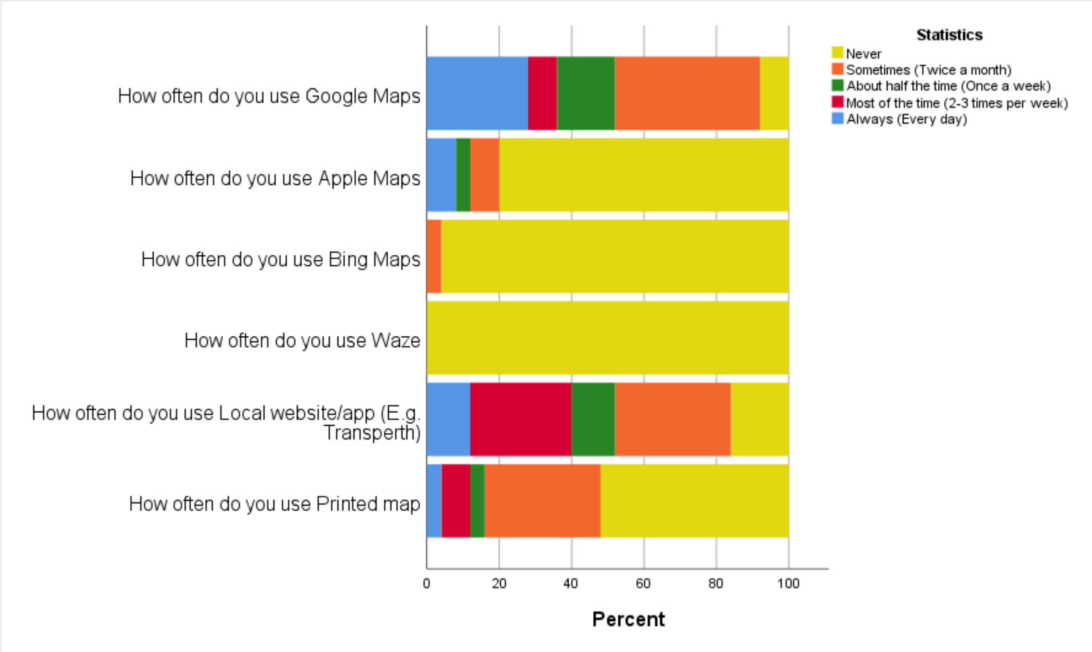


Figure 5.17 Frequency of use of transport-planning websites and printed maps

The second section of the survey was completed after each eye-tracking task was completed. The results from this section of the survey are presented in the eye-tracking results in the next section.

5.4.2 Task 1 – Searching areas of interest in four websites using their screen shots

The areas of interest (AOI) were defined as the search bar and the zoom-in/zoom-out options on each website, given that both are required when a user searches for directions. Figure 5.18 shows the AOIs in Google maps.

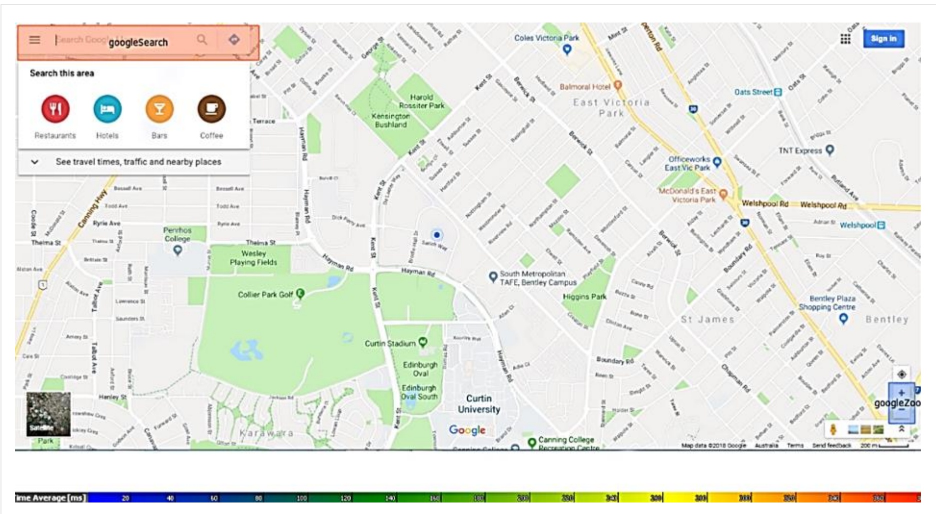


Figure 5.18 Areas of interest in Google maps

Figure 5.19 shows the AOIs in Bing Maps.

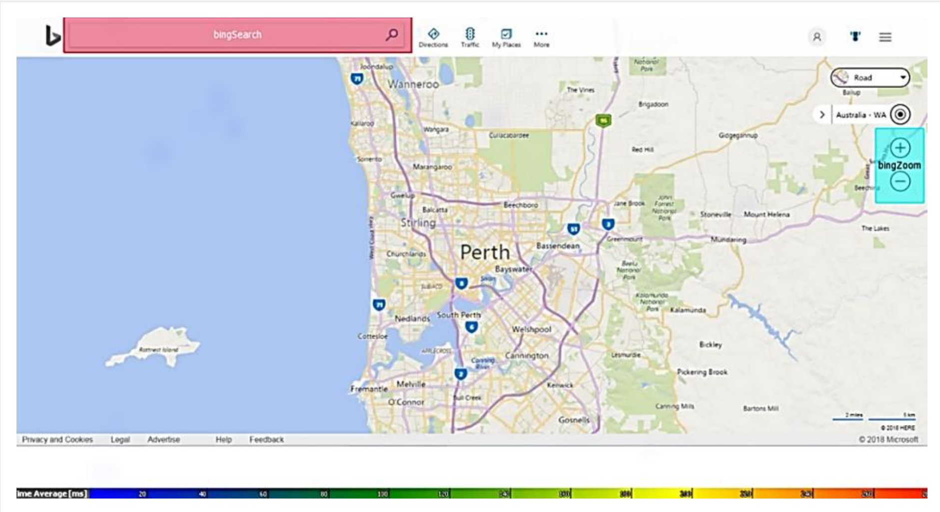


Figure 5.19 Areas of interest in Bing Maps

Figure 5.20 shows the AOI in Waze.

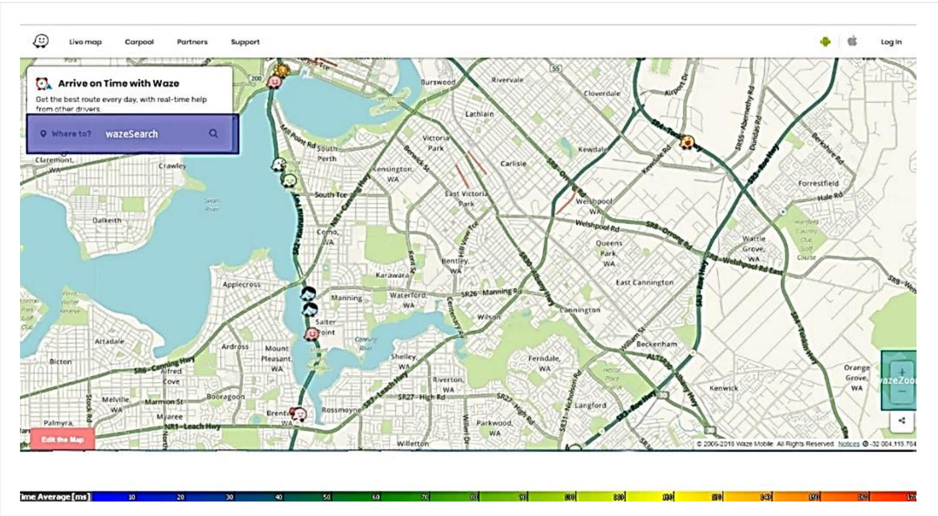


Figure 5.20 Areas of interest in Waze

Figure 5.21 shows the AOI in the Adaptable-maps website.

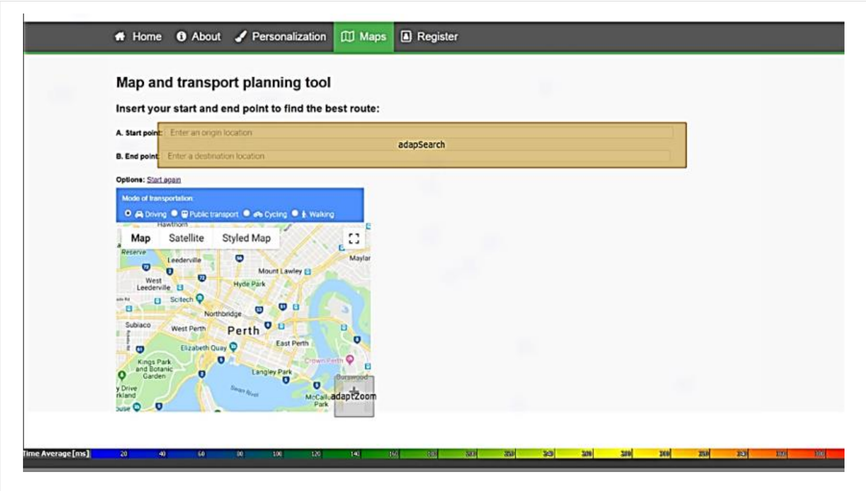


Figure 5.21 Areas of interest in Adaptable-maps

The focus map of each website shows from black to white where users fixated more. If the area appears darker the user did not fixate there but if the area is clear, more users fixated in the area. Figure 5.22 shows that the elements in the Google maps website that presented more fixations were the search box, the centre of the website, some parks and titles in the map and the zoom in/out area. The figure appears dark and could be hard to read but it is essential to explain the clear areas where the fixations were longer.

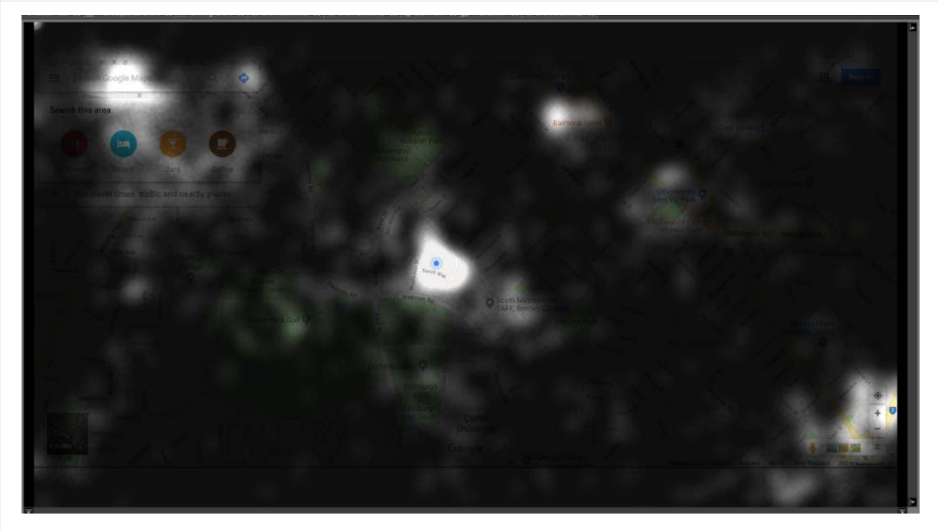


Figure 5.22 Focus map of Google maps

Figure 5.23 shows that the focus map of Bing Maps presents more fixations in the search icon corresponding to the search box, the centre of the map, the zoom in/out buttons, and the area where the user can select different styles of maps corresponding to the area above the zoom in/out buttons.

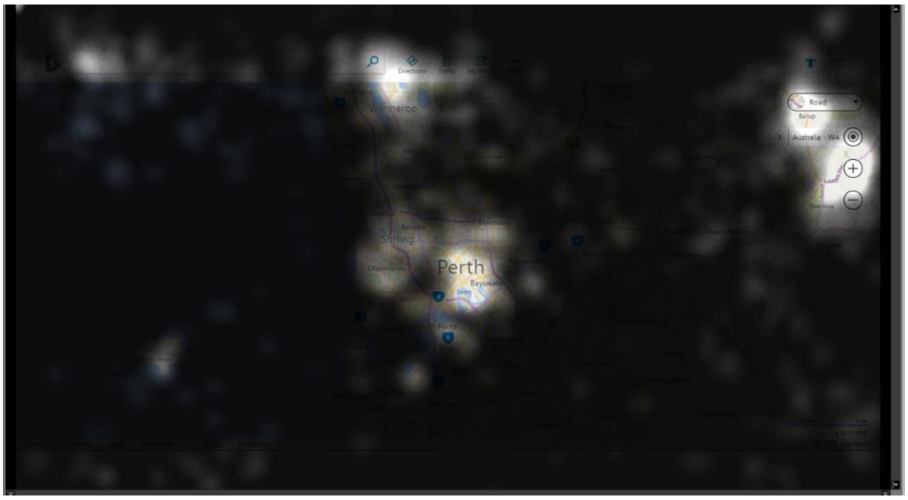


Figure 5.23 Focus map of Bing Maps

The Waze website presented many areas with fixations. Figure 5.24 had the most fixations in the search box area but the centre and many more small areas in the map presented several fixations.

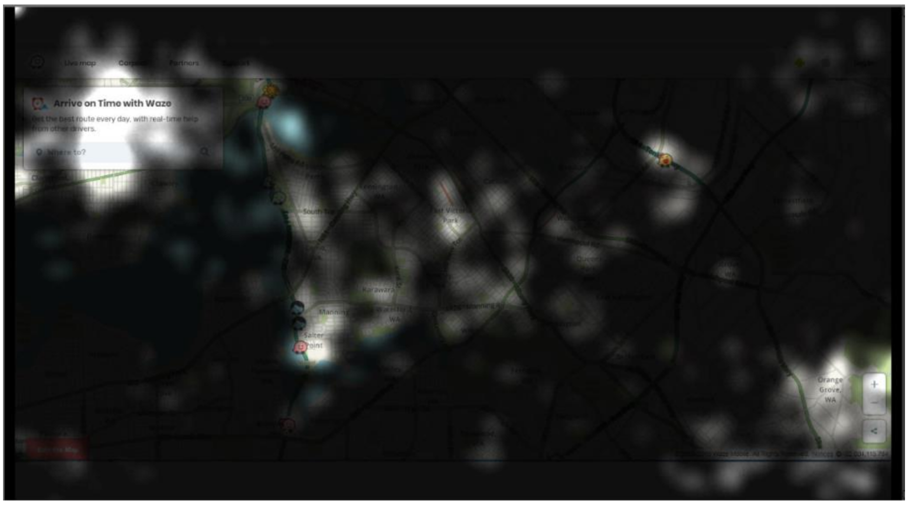


Figure 5.24 Focus map of Waze

The Adaptable-maps focus map presented in Figure 5.25 shows how the majority of fixations were concentrated in the search boxes, in the icon corresponding to full-page visualisation and in the zoom in/out buttons.

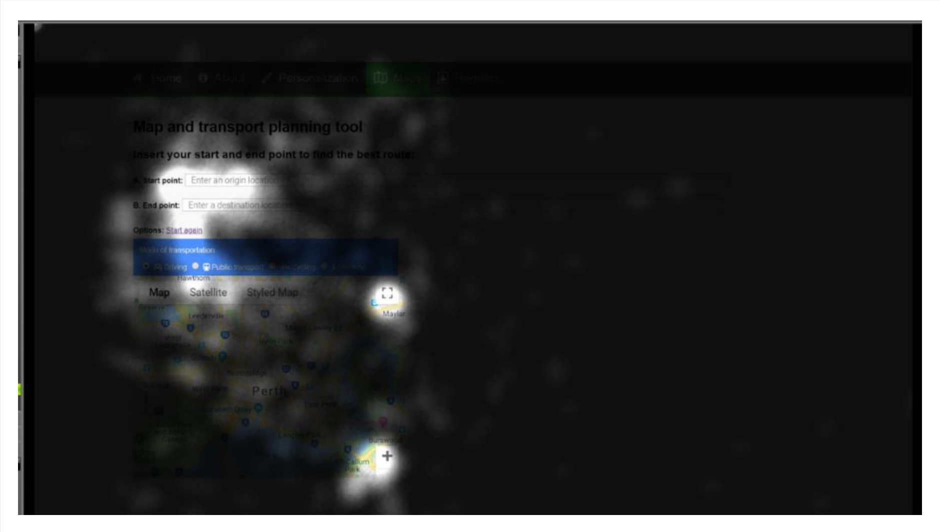


Figure 5.25 Focus map of Adaptable-maps

Similar to the information presented by the focus map, the heat map presents where the users tended to fixate more and for longer time. It uses the colour scale from blue to red as shown in Figure 5.26, with darker blue indicating the shortest and read the longest fixation time. The following four figures (Figure 5.27, Figure 5.28, Figure 5.29, Figure 5.30) show the corresponding heat map for each of the evaluated websites.

Figure 5.26 Heat map colour-scale

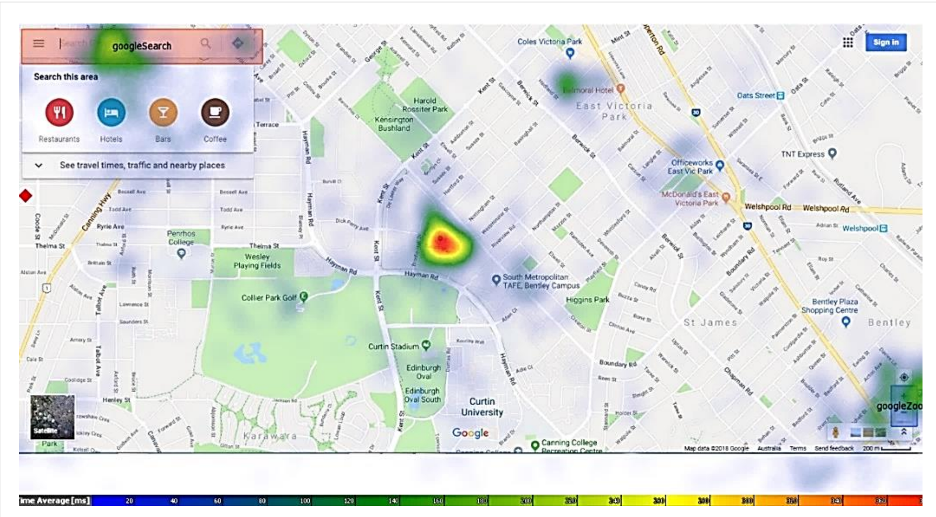


Figure 5.27 Heat map of the Google maps website

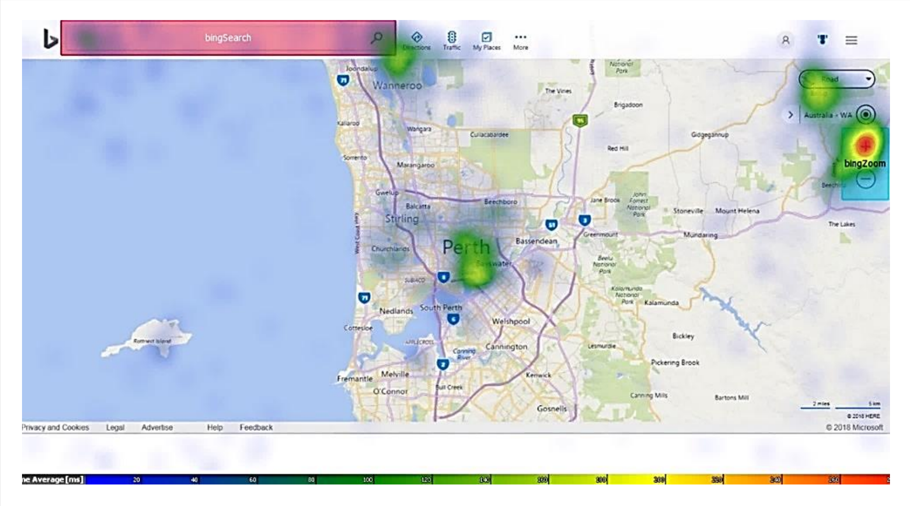


Figure 5.28 Heat map of the Bing maps website

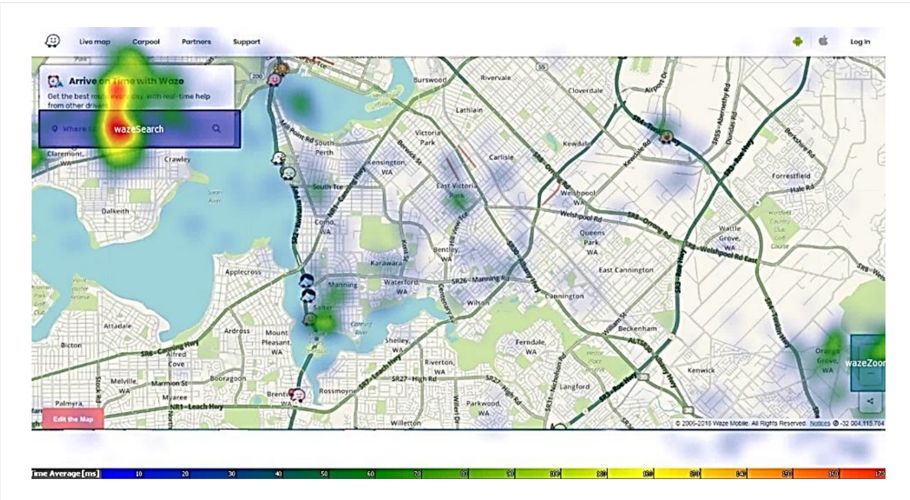


Figure 5.29 Heat map of the Waze website

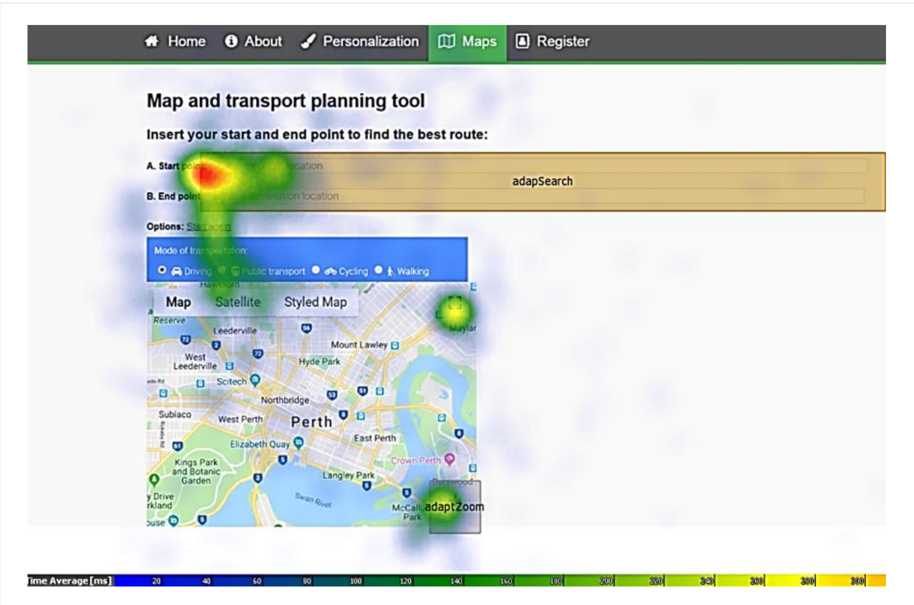


Figure 5.30 Heat map of Adaptable-maps website

Eye movements are typically divided into fixations and saccades – when the eye gaze pauses in a certain position, and when it moves to another position, respectively. The resulting series of fixations and saccades is called a scanpath, and the smaller spatial density indicates more direct search. The scanpaths corresponding to each evaluated website are presented below: Google maps scanpath is presented in Figure 5.31. The spatial density of saccades and fixations in non-relevant areas were prevalent, such as on the labels of parks, commercial or retail outlets.

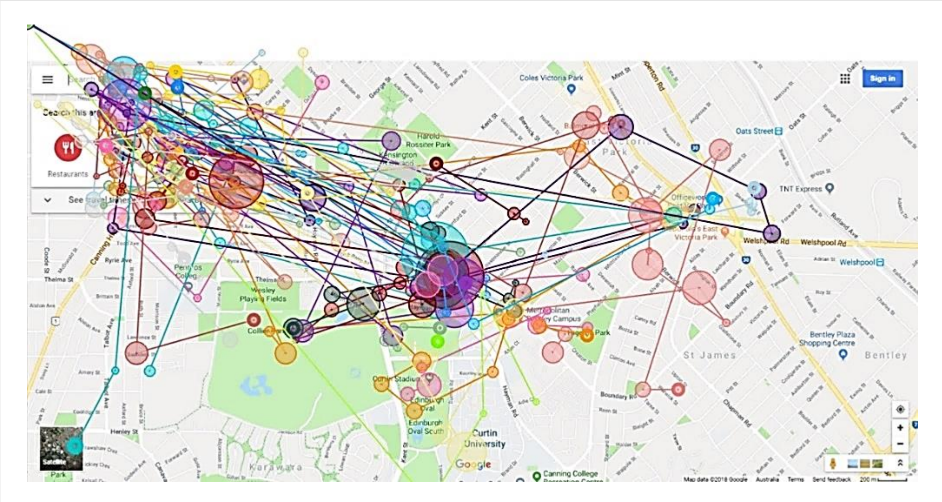


Figure 5.31 Scanpaths in Google maps

The scanpath on the Bing maps website is presented in Figure 5.32. Participants made many saccades and fixations that were not relevant to the task such as fixations on an island on the left-hand side of the map, and some menus on the top-left corner of the screen.

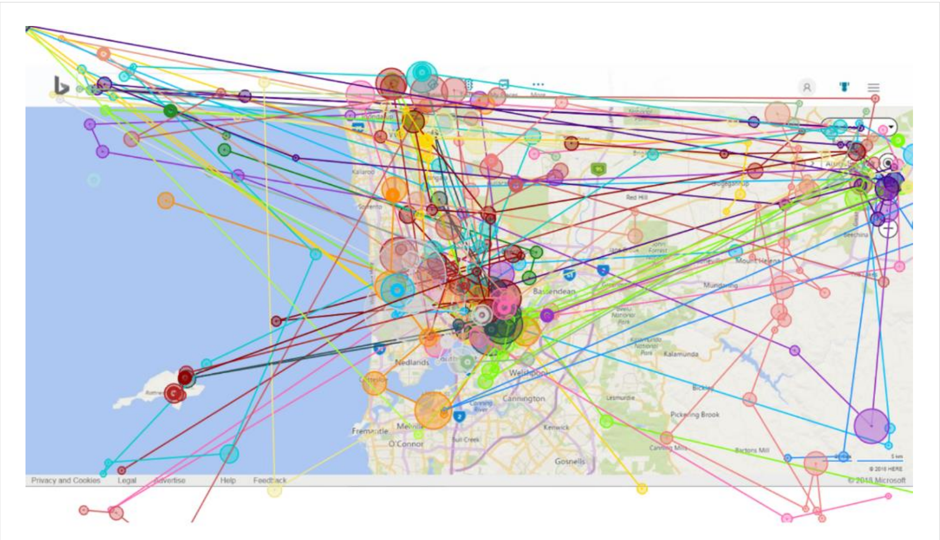


Figure 5.32 Scanpaths on the Bing maps website

The scanpath in Waze is presented in Figure 5.33. Several saccades and longer fixations were predominant showing that the map had many elements in the website that attracted attention. The spatial density of saccades is predominantly longer than in the other websites.

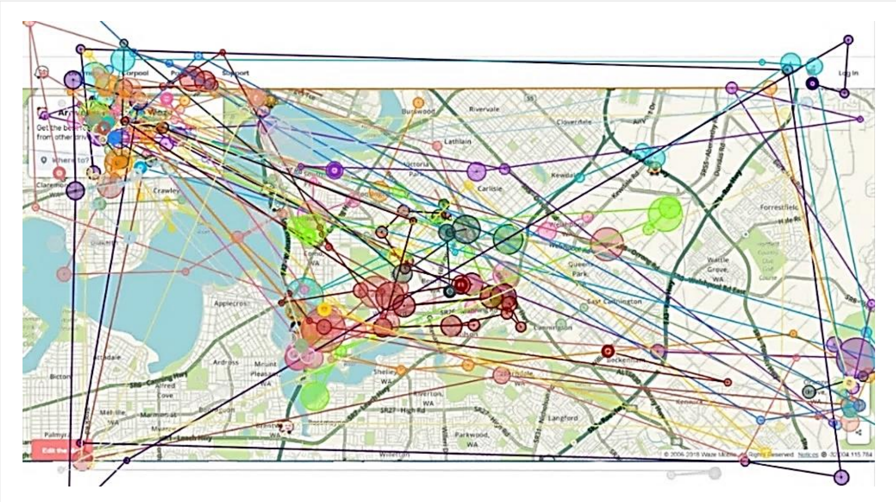


Figure 5.33 Scanpaths in Waze

The scanpath in the Adaptable-maps website is presented in Figure 5.34. This map shows that the fixations were concentrated on the left side of the website, with the majority of fixations in the area of interest of the search boxes, and in the mode of transportation menu and in the top of the map. The spatial density of saccades is shorter than in the other websites.

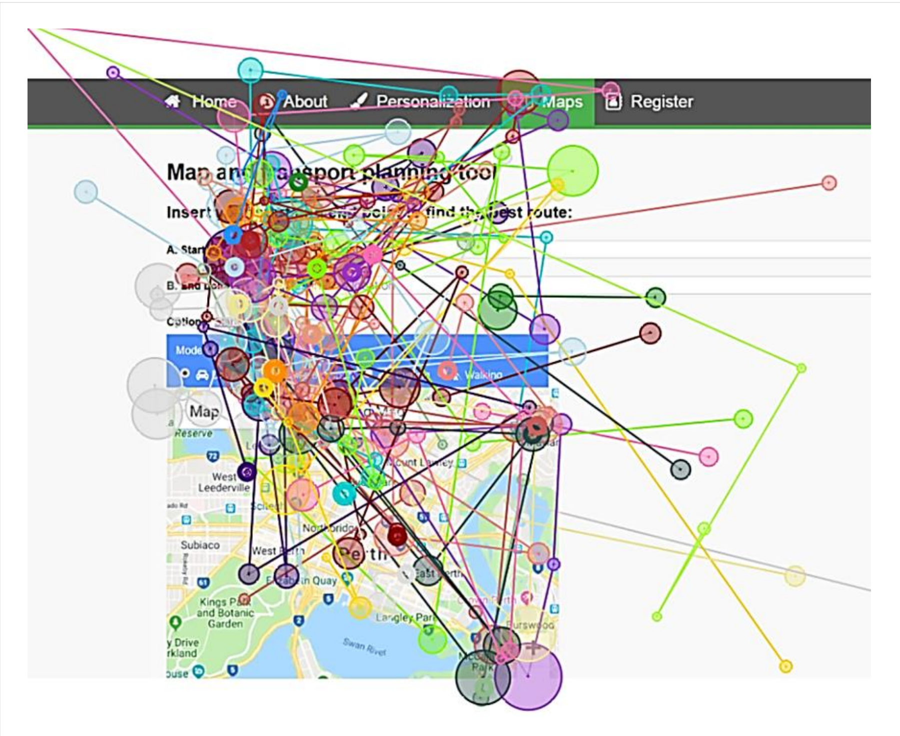


Figure 5.34 Scanpaths on the Adaptable-maps website

5.4.3 Task 2 – Searching for driving instructions

When each participant was asked to find the driving directions from a start to an end point the duration to complete the task was recorded, and the task was considered completed. It was taken into account if the user correctly selected both locations, start and end. And the duration of the task was calculated until the user answered completely the driving time from the start to the end point. To do the calculation of task duration, only fully completed tasks were taken into account. If the user selected a different location from the one instructed or if the task was not completed, the time spent in that task was not included.

List of exclusions

The duration looking for driving directions from a start to an end point from the following users and websites was not included in the calculations following these reasons:

- One user was unable to understand how to use the Waze website.
- One user was unable to understand how to use the Bing maps website.
- One user was unable to understand how to use the Google maps website.
- One user was unable to understand how to use all websites.
- Only the general question and general feedback could be included for one user as the survey did not work properly and the individual website's score could not be recorded.

From all valid data, the average duration in the task related to search for driving directions from a start to an endpoint is presented in Table 5.2. Randomly selecting one place from users that did the task in both places, the known and the unknown place, indicated that in the Adaptable-maps website the users spent on average 47 seconds, it was followed by Google maps with an average duration of 1 minute and 2 seconds, that was followed by Bing Maps which average duration recorded 1 minute and 20 seconds, and, lastly, Waze was the most complicated website to complete the tasks and users expended on average 1 minute 34 seconds.

If the calculation of average duration of the task to look for driving directions is calculated discriminating the known place (Perth) and the unknown place (Sydney) the results are as follow for Perth: in the Adaptable-maps website users spent 48 seconds, in Google maps they spent 59 seconds, in Bing maps they spent 1 minute 35 seconds, and very similar to the Bing maps website, the longest duration was registered by Waze with an average of 1 minute 36 seconds. The average duration of participants completing the task of looking for driving directions in the unknown place of Sydney, in average the durations were in the Adaptable-maps users spent 48 seconds, in Google maps they spent 1 minute 4 seconds, in Bing Maps the participants spent 1 minute 11 seconds, and in the Waze website they spent 1 minute 14 seconds.

Table 5.2 Average duration looking for driving directions

	Google maps	Bing maps	Waze	Adaptable-maps
Random place	0:01:02	0:01:20	0:01:34	0:00:47
Known place	0:00:59	0:01:35	0:01:36	0:00:48
Unknown place	0:01:04	0:01:11	0:01:14	0:00:48

5.4.4 Websites comparison and web accessibility feedback

The websites comparison presents the results after the participants evaluated all four websites and provided their feedback about each of them. General notes and observations about the web accessibility feedback are listed as well.

5.4.4.1 Websites comparison

After completing the task to look for driving directions, the participants were asked to give feedback on the experience using the website and give them a score out of ten, being ten the highest and best score. The following results were obtained:

Six participants evaluated three websites: Adaptable-maps website, the Bing Maps website and the Waze website. Table 5.3 shows the scores that the participants provided when asked to qualify their general user experience in the website on a scale out of ten, being 10 the maximum and best score possible. Bing maps obtained the highest score with an average of 6.25, followed by the Adaptable-maps with 6.08 and finally Waze obtained a score of 4.

Table 5.3 Website's evaluation, user experience individual score of three websites: Adaptable-maps, Bing maps, and Waze

	N	Minimum	Maximum	Mean	Std. Deviation
Adaptable-maps score	6	0.00	9.00	6.08	3.13
Bing Maps Score	6	4.00	7.50	6.25	1.50
Waze Score	6	2.00	6.00	4.00	1.41
Valid N (listwise)	6				

When Google maps was included to be compared against the other websites the results shown that Google maps was scored highest with 8.4, Adaptable-maps had a score of 8, Bing maps had a score of 5.9 and Waze of 4.8. Details are included in Table 5.4.

Table 5.4 Website's evaluation, user experience individual score of four websites: Adaptable-maps, Google maps, Bing maps, and Waze

	N	Minimum	Maximum	Mean	Std. Deviation
Adaptable-maps score	18	4.00	10.00	8.00	1.65
Google maps score	18	2.00	10.00	8.38	2.03
Bing maps score	18	2.00	10.00	5.94	2.31
Waze score	18	2.00	10.00	4.83	2.30
Valid N (listwise)	18				

The participants were asked to select their most preferred website after they used all websites and the most preferred transport-planning website among the 25 participants was Google maps, which was selected by 13 participants (52%), followed by Adaptable-maps which was selected by 8 participants (32%), Bing Maps was selected by 4 participants (16%), and no one selected Waze as their most preferred website.

The website considered to be the most complicated to use was Waze, selected by 17 participants (68%) followed by the Adaptable-maps selected by four participants (16%), Bing maps was selected by three participants (12%), and finally Google maps was selected by one participant corresponding to 4%.

The website voted as the easiest to use was Google maps, selected by 11 participants (44%), followed by Adaptable-maps selected by nine participants (36%), Bing maps was voted by three participants (12%), and Waze was selected by two participants (8%).

5.4.4.2 Web accessibility feedback

The following section of the survey explored open ended questions aiming for participants' opinions about web design and web accessibility and the results were as follow.

Most annoying problems in websites

The most annoying problems when using different websites were reported to be related to:

- Colour contrast.
- Finding buttons and icons in difficult spots.
- Websites not loading, glitches and latency problems.
- Difficulties in navigating the website. One user said:

  "Being unable to figure out how to use the website. It is very annoying if I feel like I am taking a much longer time than I have to figure out where to find the information I want."

- Too many options on a single page. One user expressed:

  "In general, when a website and app shows a screen full of features that you more or less have no idea what they do without a help feature is common problem (introducing a short tutorial?)."

Some important and relevant features were reported to be:

- Options to personalise the interface are well received. E.g. font style, size and spacing. As well as being able to set different colour contrast between font and background.
- Simplicity. One user said:

  "Minimalist approach. I don't need to see all the information, just the stuff relevant to me."

Important features

The most important features in a transportation website were listed as: [having an] easy way to find the contact information details, fees information, [being able to] find directions easily, clear and understandable icons, the map style showing enough contrast, and [being] able to select different style preferences. Some users also said: to have real-time updates and being able to score the service.

Irrelevant features

The less important features in a transportation website were listed as: the bicycle and walk icon, all non-functional or cosmetic functionalities, the street view and the terrain option.

5.4.4.3 Most preferred user interface elements by participants

When the participants used the Adaptable-maps website they needed to select the user interface elements that they liked the most. After summarising all preferences the following combinations of user interface elements were selected by the majority of users: white background, Arial font, font in black colour, medium size font, normal font spacing and buttons colour-filled. It will be referred to as the most preferred user interface combination.

This combination of user interface elements was selected to be modelled in the webDesigASD ontology as the autism profile web interface. This means that when a user did not have any preferences and went by the default profile, the system already had the user interface combination that was most preferred by the participants in the current study, so the user interface was presented according to this combination of colour and sizes.

5.5 Discussion and conclusions

The implementation of a website related to transport-planning called Adaptable-maps helped to compare current web mapping websites (Google maps, Bing Maps and Waze) and to explore if they are accessible for people on the autism spectrum. The most well-known transportation-planning website was Google maps, and it was also the one preferred by the majority of participants. As a result, the current study was able to explore how a totally new website might compare with a very familiar website such as Google maps, and how they compare with other websites in the market that are not as well known by participants.

The eye-tracking data demonstrated that even though Google maps was the most popular website for web transport planning, it was not the most efficient website when participants were looking for driving directions measured in time to complete the task. The data exposed that users had to perform more and longer saccades when using Google maps compared with the Adaptable-maps website when they were required to find information. Despite this, participants scored Google maps higher. It is known that change can be hard to process for people on the autism spectrum (Daniels & Mandell, 2014). It is possible that the familiarity factor added more to their preferences than the efficiency factor. As they were more familiar with the Google maps website it is possible that they preferred to use a website that was less accessible but better known to them.

The eye-tracking data generated focus maps, heat maps and scanpath images that demonstrate that the autistic users in the current study got easily distracted by irrelevant elements in websites. For example, Google maps had icons in parks and titles in commercial/retail places and users were fixating in those areas when they were looking for driving instructions. These icons and labels are not relevant to perform the search but as they have small icons and label on the map, users tend to fixate on them. Another example is that Bing Maps had a menu to change the style of the map in the left top section of the website, and it was greatly fixated on by the participants while not having any relevance to the search for driving instructions. In Waze, the little comic icons around the map distracted all participants; fixations and saccades on this website were the highest of all four websites evaluated. As the mode of transport is not explicit in Waze, all participants hesitated and were looking for an icon or title explaining which was the mode of transport in which the directions were presented. In the Adaptable-maps website the icon for changing the map to full screen caught the attention of several participants causing fixations when it was an irrelevant option in the map for the given task.

Many users approved the use of two different boxes for search directions, one box for the start point and another box for the destination point. The Adaptable-maps website was the only one with that option.

One user did not know how to use any transport website. This was a very critical finding that should be addressed in future research. Four other participants did not know how to use some or other of the websites.

Some users believed they had completed the task when it was not the case, as the location they found was incorrect. For example, in the case of Perth Station, there is another place called Perth Rail Station that it is located on the North-side of the city. Some participants used the Perth Rail Station to answer the questions of the experiment without realising that they had selected the wrong place and the driving directions were not correct.

Longer scanpath lengths on a webpage are related to less efficient searching as more elements are tracked visually as part of completing a task. The scanpaths showing users' visual attention in Google maps, Bing Maps and Waze presented long and multiple paths, demonstrating that users were constantly changing focus and fixating on elements that were at a distance from each other. The scanpath in the Adaptable-maps website presented shorter and closer paths demonstrating that the most relevant elements for users were closer to each other, an advantage for more efficient searching.

In conclusion, the implementation and evaluation of the Adaptable-maps website demonstrated that following the web design accessibility guidelines presented in Chapter 3 and the ontology-based design presented in Chapter 4, resulted in the creation of an accessible website that allowed autistic users to make more efficient searches by requiring shorter scanpaths and total time-duration when compared with current transport-planning websites (Google maps, Bing Maps and Waze).

The following chapter, Chapter 6, lists the contributions and future work found by this research.

Chapter 6 Contributions and future work

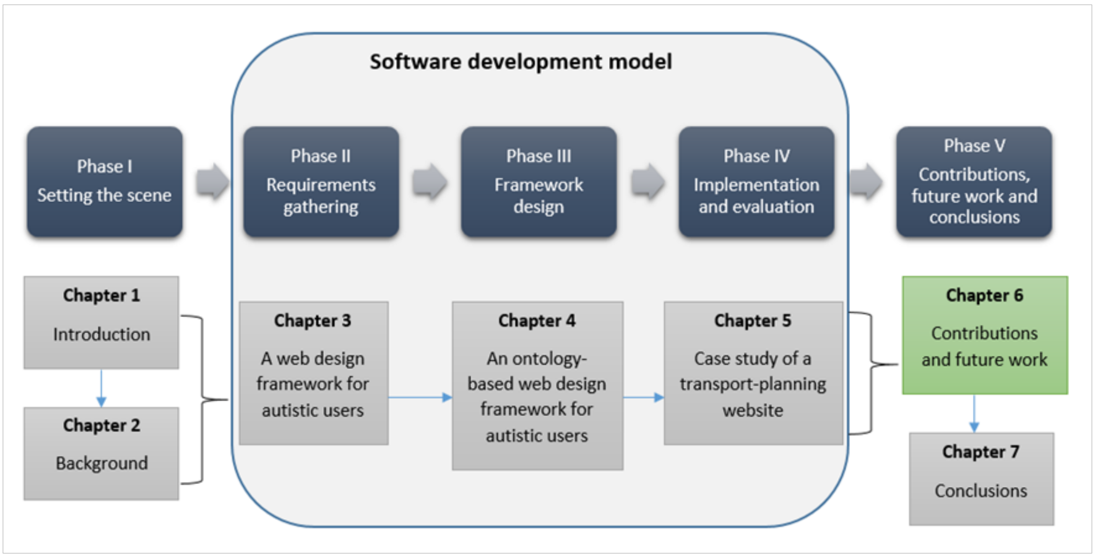


Figure 6.1 Chapter 6 in the context of the thesis structure

Chapter 6, as depicted in Figure 6.1, explains the different contributions of this research to different areas of knowledge and lists some of the future work that should be explored.

6.1 Contributions

The novel and significant contributions of this thesis to the knowledge of web accessibility for autistic users are framed in three areas: (1) the integrated web interface accessibility guidelines for creating accessible websites for users on the autism spectrum, (2) the ontology-based design framework which includes the creation of the webDesignASD ontology, and (3) the evaluation of the transport-planning websites, which demonstrated that the implementation of the web interface design guidelines and the ontology-based framework facilitate the creation of accessible websites for users on the autism spectrum.

1. The integrated web interface accessibility guidelines for creating accessible websites for users on the autism spectrum

   The background research that informed the aims for this thesis revealed that no centralised web interface design guidelines existed for creating accessible websites for people on the autism spectrum. The 13 web interface design guidelines presented in this thesis are the outcome of an extensive scoping review that reviewed the current state of knowledge about web accessibility for autistic users. The fact that the results from the review was presented to end-users in a consultative process helped to further the understanding of the importance and prioritisation of these guidelines. This compilation is a valuable resource for anyone interested in improving the web user experience for people on the autism spectrum or for other neurodiverse users. As suggested in this thesis, improving the web user experience for autistic people helps to improve the web experience for the whole community. The web design guidelines offered here facilitate the creation of websites that support people with diverse physical and mental conditions by improving usability, navigation and therefore understanding. The applicability of the results presented in this thesis can be applied to a different population.

2. The ontology-based design framework

Semantic web technology has been gaining momentum and now that the world is coming into the 4th technology revolution – namely, the Internet of things, big data and data mining – it is imperative to share knowledge and cooperate with the machine-to-machine language evolution. Websites that are filled with static and restricted information are a thing of the past. Semantic web technologies, such as ontologies, contribute to the standardisation and sharing of knowledge between domains. Combining knowledge of the autism condition and web user interfaces have previously been studied but the approach presented in this thesis relates to a web design ontology that in itself includes the autism condition. This is totally novel and presents a new approach to solving the research questions of how to improve the web user experience for autistic users based on their needs and preferences.

The web design presented in this thesis can be used by any web developer, in any field, and if the provided guidelines are followed, it will help to improve the web design of any website, allowing it to be more personalised, user-targeted and adapted to the personal profile of the user.

3. The evaluation of the transport-planning websites

The creation and implementation of the transport-planning website Adaptable-maps and its evaluation with current websites highlighted several issues concerning the web user experience of autistic users. These issues could easily be improved if the web design guidelines presented in this thesis are implemented. All evaluated websites presented different challenges for all participants, and it was demonstrated that the most well-known and familiar website is not always the most accessible.

The evaluation of both the user experience (survey) and the user behaviour (eye-tracking) presented results that complement each other. This approach was novel in order to obtain information about web usability and web accessibility that would not be possible to obtain if they were used independently.

Implications for web developers

The findings of this thesis greatly assist web developers who aim to understand and learn more about web accessibility for users on the autism spectrum, and for the whole community. The web design guidelines presented in this thesis are fully explained and include examples of how to implement them in websites. Furthermore, they were analysed, validated and tested by users on the autism spectrum clearly demonstrating their effectiveness.

Implications for researchers of semantic web technologies

Semantic web technologies demonstrate what research is truly about: that is, collaboration and the sharing of information. There is no point in conducting extensive research only to not share the results and to not expect collaboration and growth. Many previous studies about web design and web accessibility for users on the autism spectrum or related conditions were included in the design of the webDesignASD ontology, which was the basis of the web design framework implementation. The author of this thesis expects that this research can open the discussion towards improvements in the domain of web accessibility for people on the autism spectrum as the ontology evolves and more results are obtained. Ontologies and semantic technologies are vivid assets that should be used by many users in order to discover opportunities for improvement. This ontology and design will not be the exception.

Implications for web mapping developers

Web navigation and physical transportation are activities that most humans need on an everyday basis. Any improvement and effort to integrate these two worlds are always welcome for the wellbeing of the whole community. This thesis revealed several ways in which transport-planning websites could be developed in order to improve the web user experience for users on the autism spectrum, but they will also help many other web users according to the principle of "solve for one, extend to many" (Microsoft, 2019). Web developers working on transportation-planning websites have proven data to improve their websites.

6.2 Limitations

Absence of a control group during the website's evaluation

The website's evaluation presented in this thesis did not have a control group due to time limitations. However, the author acknowledges that having a control group of non-autistic web users could have provided the opportunity for further comparisons between both groups of users.

Eye-tracking data

The quality of the data recorded from the eye-tracking apparatus could have been affected by factors not related to participants' actual eye movements. The apparatus used during the eye-tracking evaluations was head-free which means that after calibrating the device, there could have been times where users performed head movements that could cause some data to be lost due to the eye gaze being out of the maximum radios possible to be recorded by the apparatus. This setting, however, represented a more real-life situation and to "fixate" the participant's heads may have resulted in a more pretended scan pattern.

The eye-tracking device was recording during the task where participants were asked to search for driving directions on different websites, however, the data generated from the eye-tracker during this type of live screen-recording was not used in the analysis because the areas of interest and the context of each website were dynamic and totally different from each other invalidating any potential comparison between websites.

Linked ontologies not available

There were several original ontology files (the actual file named *.owl) related to the newly created webDesignASD ontology that could not be located. Hence, it was not possible to document and link these related ontologies in the documentation of the webDesignASD ontology. Nevertheless, it was recorded in which publication or study the related ontology was published. As an ontology is a live computable file, the author expects that when more ontologies related to web accessibility for autistic users become available, they will be integrated into the created ontology.

6.3 Future work

Non-desktop websites

This research focused on web interfaces for desktop browsers but there are many other interfaces to be analysed such as software applications, mobile phone interfaces, tablets and wearables. Internet of Things is generating multiple studies as to how humans will be able to communicate better in a screenless world. Questions of accessibility when users are navigating the Web without the use of a screen would be a very interesting way to expand the research presented in this thesis.

Research-based on autism severity

The autism condition has different levels of severity according to the Diagnostic and Statistical Manual of Mental Disorders 5 (DSM-5). The results obtained in the website's evaluation represented the point of views and behaviour of autistic individuals with limited support needs. However, the focus group included parents, careers and community members of autistic individuals with higher support needs as an effort to also have their needs and preferences voiced. There is an opportunity to enhance the future research of web accessibility if autistic web users on different levels of severity are directly included in the evaluations.

A case study from a different domain

This thesis implemented and evaluated a website in the domain of transport-planning websites but the implementation of the web design guidelines and the web design framework can be used in any domain or field. It would be very interesting to see results from implementation in different domains such as education or tourism.

Machine learning implementation

The participants that were included in the evaluation of the Adaptable-maps website study that was explained in Chapter 5, selected their preferred combination of web user interface elements, and the combination that obtained the most participants' preferences was: Arial black font type in a normal size (10 pts), in a normal spacing of 1.0, on a background in white colour, with buttons colour-filled. This is the combination that the Adaptable-maps website presents as its web interface if no preferences have been selected.

It would be of benefit to the development of the ontology if many more user preferences could be saved in order to update the basic autism profile stored in the system based on selections by the greatest number of users. The selected preferences for the majority of autistic users could also be considered as a cluster of preferences for web interfaces for autistic users and could be replicated on any other website.

Chapter 7 Conclusions

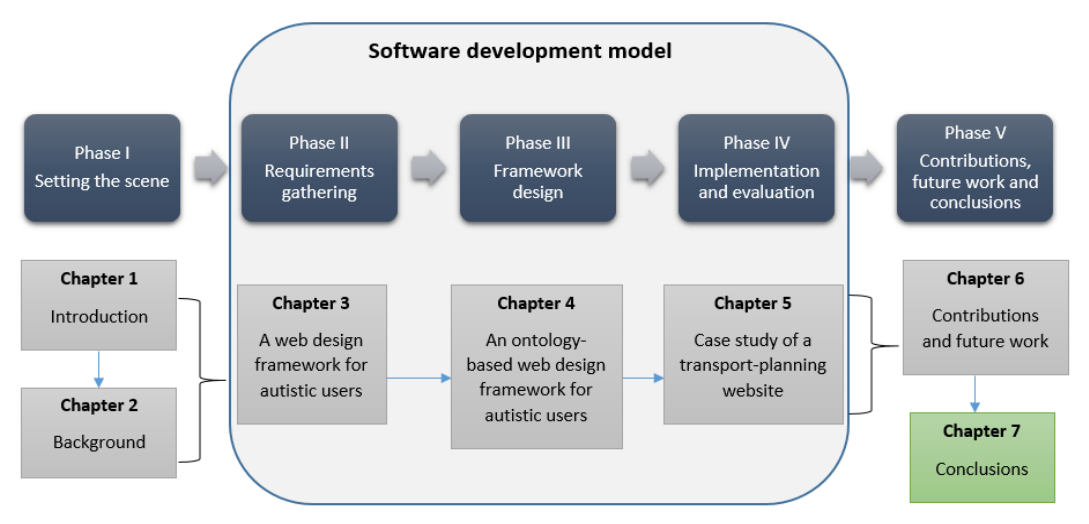


Figure 7.1 Chapter 7 in the context of the thesis structure

Chapter 7, as depicted in Figure 7.1, presents the conclusions of this work.

7.1 Key findings

The overall aim of this thesis was to create integrated web design guidelines for users on the autism spectrum, explaining the process from requirement specification to implementation. It was demonstrated through five phases: setting the scene, requirements gathering, framework design, software implementation and evaluation, and contributions, future work, and conclusions. Each phase presented its objectives and results, with a focus on the novel and significant contributions to the knowledge of web accessibility of users on the autism spectrum.

The evidence presented as findings in this research suggests that websites that follow web accessibility guidelines targeted for users on the autism spectrum improve the level of functioning of autistic users when they navigate and search on transport-planning websites. The behavioural patterns found in the eye-tracking study validate that the 13 web design guidelines are valid and useful when they suggest that simplicity and consistent navigation are important for users on the autism spectrum when navigating desktop websites. All 13 web design guidelines are relevant and should be followed to improve the web user experience for users on the autism spectrum and for all users who navigate the Web.

In line with this assumption, if current transportation-planning websites implement some improvements in their websites based on the evidence presented in this research, the immediate web user experience for those who navigate websites on a day-to-day basis will be improved. And, as a consequence, more users will use websites in a more efficient way, and their web user experience will be enhanced.

7.2 Contributions to knowledge

The three main contributions to the knowledge of web accessibility for autistic users presented in this thesis were (1) the integrated web interface accessibility guidelines for creating accessible websites for users on the autism spectrum, (2) the ontology-based design framework which included the creation and implementation of the webDesignASD ontology, and (3) the evaluation of the transport-planning websites, which demonstrated that the implementation of the web interface design guidelines and the ontology-based framework facilitate the creation of accessible websites for users on the autism spectrum.

These contributions were novel, insofar as there was no centralised and evidence-proven web interface design guidelines to create accessible websites for users on the autism spectrum, there was no an ontology-based design in which the autism condition was modelled as an ontology taken into account the relationship with the different user interface elements that affect the web user experience, and the case study of the implementation of both concepts in the context of transport-planning websites evidenced several issues that current websites have affecting the web user experience of autistic users.

7.3 Significance of contributions

The key findings are significant because the 13 web design guidelines are the result of extensive background research in which several research methods were required to follow to obtain the final list of results presented in this research. These 13 web design guidelines merged a large number of web design guidelines into a manageable number that should be possible to follow for web designers or anyone interested in improving the web user experience of autistic users. The ontology-based framework is significant because it reused and extended several ontologies that were related to web accessibility for autistic users with the creation of the webDesignASD ontology, and this is the baseline that web developers and semantic web researches can use to continue improving the web experience for users on the autism spectrum. Furthermore, the results from the case study of transport-planning websites is significant because it demonstrated that the implementation of the 13 web design guidelines and the ontology-based framework presented in this thesis, provided a useful strategy to create a website that facilitated understanding, readability, and search efficiency for users on the autism spectrum.

To conclude, the research presented in this thesis has assembled best-practice web design guidelines for web usability in Chapter 3, created a semantic web design with the implementation of the webDesignASD ontology in Chapter 4 and proven its value in a case study in Chapter 5. The findings in this thesis highlight the need for awareness and intervention in web accessibility for users on the autism spectrum to improve their web user experience when navigating desktop websites. The approach to improve the web user experience for users on the autism spectrum will help to improve the web user experience of the whole community.

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APPENDICES

Appendix A Study ethics approval and related forms

Curtin University

Office of Research and Development

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11-Sep-2017

Name: David McMeekin
Department/School: Department of Spatial Sciences
Email: D.Mcmeekin@curtin.edu.au

Dear David McMeekin

RE: Ethics approval
Approval number: HRE2017-0621

Thank you for submitting your application to the Human Research Ethics Office for the project **Prototype for user interfaces for people with autism**.

Your application was reviewed by the Curtin University Human Research Ethics Committee at their meeting on **05-Sep-2017**.

The review outcome is: **Approved**.

Your proposal meets the requirements described in National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007)*.

Approval is granted for a period of one year from **11-Sep-2017** to **11-Sep-2018**. Continuation of approval will be granted on an annual basis following submission of an annual report.

Personnel authorised to work on this project:

Name	Role
McMeekin, David	CI
Tan, Tele	Supervisor
Falkmer, Marita	Supervisor
De los Rios Perez, Claudia	Student

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
    - proposed changes to the approved proposal or conduct of the study
    - unanticipated problems that might affect continued ethical acceptability of the project

- major deviations from the approved proposal and/or regulatory guidelines
- serious adverse events

3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)
4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a completion report submitted on completion of the project
5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
8. Data and primary materials must be retained and stored in accordance with the Western Australian University Sector Disposal Authority (WAUSDA) and the Curtin University Research Data and Primary Materials policy
9. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
10. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
11. Ethics approval is dependent upon ongoing compliance of the research with the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research, applicable legal requirements, and with Curtin University policies, procedures and governance requirements
12. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Special Conditions of Approval

This letter constitutes ethical approval only. This project may not proceed until you have met all of the Curtin University research governance requirements.

Should you have any queries regarding consideration of your project, please contact the Ethics Support Officer for your faculty or the Ethics Office at hrec@curtin.edu.au or on 9266 2784.

Yours sincerely

Professor Peter O'Leary
Chair, Human Research Ethics Committee

Curtin University

Personalized user interface for people with autism

PARTICIPANT INFORMATION STATEMENT

HREC Project Number:	HRE2017-0621
Project Title:	Personalized user interface for people with autism
Chief Investigator:	Dr David A. McMeekin
Student researcher:	Claudia De Los Rios Perez
Version Number:	**1.0**
Version Date:	**24/08/2017**

What is the Project About?

People with autism rely on technology to gain independence. The user interfaces on mobile phones, tables, computers and wearables need specific adaptations to be useful for people on the spectrum. This research aims to adapt the user interface based on your personal skills, capabilities and strengths. Ontologies and semantic web technologies are the backbone to this framework.

There have been several attempts to create user interfaces for people with autism but any of these have included the autism ontology and the semantic technologies during their design and analysis. Our hypothesis is to validate that with an adaptable user interface, you will be able to perform better and will have more confidence during the transportation process.

This project will need 30 participants. The participants are independent adults diagnosed with high functioning autism and no other mental condition such as intellectual disability.

Who is doing the Research?

The project is being conducted by Dr David McMeekin and the results of this research project will be used by PhD Candidate Claudia De Los Rios Perez to obtain a Doctor of Philosophy at Curtin University and is funded by the University.

There will be no costs to you and you will receive a gift card as a token for participating in this project.

Why am I being asked to take part and what will I have to do?

You have been asked to take part because you have the condition we are researching and your contributions will help to comprehend how to better adapt user interfaces for more people in your same situation. Being part of the evaluation will involve:

- You attend a computer room at Curtin University where we will assign a computer for you to complete a survey about transportation. You will need 5 minutes for this task.

- After the survey, you will do some tasks while your eye movements are recorded using a remote eye tracker. You won't need to leave the room, as everything will be performed while you are seated manipulating your device. You will take about 10 minutes to complete this task.
- At the end of the evaluation, you will fill out a 10 minutes electronic survey. The survey focuses on how you experienced the user interface and if you can compare it as more reliable and useful as other tools you have used before.
- A second evaluation is required after you set your preferences on the interface.
- The three phases will last about 20 minutes and you will need to complete it once.
- We will make a digital audio/video recording so we can concentrate on what you have to say and not distract ourselves with taking notes. After the interview/focus group we will make a full written copy of the recording.

Are there any benefits' to being in the research project?

We hope the results of this research will allow us to:

- promote the development of autism friendly user interfaces
- add to the knowledge we have about autism

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?

There are no foreseeable risks from this research project.
We have been careful to make sure that the questions in the survey do not cause you any distress. But, if you feel anxious about any of the questions you do not need to answer them. If the questions cause any concerns or upset you, we can refer you to a counsellor.

Who will have access to my information?

The information collected in this research will be non-identifiable (anonymous). This means that we do not need to collect individual names. No one, not even the research team will be able to identify your information. Any information we collect and use during this research will be treated as confidential. The following people will have access to the information we collect in this research: the research team and, in the event of an audit or investigation, staff from the Curtin University Office of Research and Development.
Electronic data will be password-protected and hard copy data (including video or audio tapes) will be in locked storage.
The information we collect in this study will be kept under secure conditions at Curtin University for 7 years after the research has ended and then it will be destroyed.
The results of this research may be presented at conferences or published in professional journals. You will not be identified in any results that are published or presented.

Will you tell me the results of the research?

If you provide your contact details, we will let you know the results at the end of the project. These results will not be individual but based on all the information we collected as part of the evaluation.

Do I have to take part in the research project?

Taking part in the evaluation is voluntary. It is your choice to take part or not. If you decide to take part and then change your mind, that is okay, you can withdraw at any time. You do not have to give us a reason; just tell us that you want to stop. It is not a problem and it will not affect your

Curtin University

Personalized user interface for people with autism

relationship with the project team or Curtin University. If you leave the study we will use any data we have collected, unless you tell us not to.

What happens next and who can I contact about the research?

If you decide to take part in this research we will ask you to sign the consent form. By signing it is telling us that you understand what you have read and what has been discussed. Signing the consent indicates that you agree to be in the research. Please take your time and ask any questions you have before you decide what to do. You will be given a copy of this information and the consent form to keep.

At the start of the questionnaire, available before completing the simulation, there is a checkbox to indicate you have understood the information provided here in the information sheet.

The contact persons for the evaluation is Claudia De Los Rios Perez who can give you more information and answer your questions. Her contact details are at the end of this document.

If you decide to take part in the evaluation, this will be the process:

1. Please contact Claudia via email or phone.
2. You will then receive a date when we meet to decide which days you will be doing the simulation. Information on how to get to the meeting room will be provided.

Ethics Clearance

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2017-0621). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

Ph.D. Candidate Claudia De Los Rios Perez
Curtin University
Claudia.delosriosperez@curtin.edu.au

Appendix B Detailed table of guidelines and corresponding web development element sorted by Author/Study

Author/Study	Web development element	Guideline title
Britto and Pizzolato, 2016	Scope	Allow color, text size and font customization for interface elements
Britto and Pizzolato, 2016	Scope	Be succinct, avoid writing long paragraphs and use markups that facilitate the reading flow such as lists and heading titles
Britto and Pizzolato, 2016	Scope	Enable a reading or printing mode for activities involving reading and concentration
Britto and Pizzolato, 2016	Scope	Provide audio instructions and subtitles for texts, but ensure that this is not the only alternate content representation
Britto and Pizzolato, 2016	Scope	Provide clear instructions and orientation about tasks to ease the user understanding of the content and the content language, in order to stimulate, motivate and engage the user
Britto and Pizzolato, 2016	Scope	Provide information in multiple representation, such as text, video, audio and image for better content and vocabulary understand, also helping users focus on content
Britto and Pizzolato, 2016	Scope	Provide options to customize information visualization with images, sound and text according to individual user's preferences
Britto and Pizzolato, 2016	Scope	Provide options to customize the amount of element in the interface, their arrangement and enable features personalization
Britto and Pizzolato, 2016	Scope	Symbols, pictograms and icons should present a textual equivalent near to facilitate symbol understanding and contribute to enrich user's vocabulary
Britto and Pizzolato, 2016	Scope	The Website or Web application must not rely only in text to present content. Provide alternative representations through image, audio or video and ensure that they will be close to the corresponding text

Author/Study	Web development element	Guideline title
Britto and Pizzolato, 2016	Scope	Touch screen interactions should have the appropriate sensibility and prevent errors in selections and accidental touch in interface elements
Britto and Pizzolato, 2016	Scope	Use a simple visual and textual language, avoid jargons, spelling errors, metaphors, abbreviations and acronyms, using terms, expressions, names and symbols familiar to users' context
Britto and Pizzolato, 2016	Skeleton	Allow images magnification for better visualization and ensure they continue to be understandable when enlarged
Britto and Pizzolato, 2016	Skeleton	Avoid using elements that distract or interfere in focus and attention. In case you use it, provide options to suppress those elements on screen.
Britto and Pizzolato, 2016	Skeleton	Use bigger icons, buttons and form controls that provide appropriate click/tap area and ensure that the elements look clickable
Britto and Pizzolato, 2016	Skeleton	Use blank spaces between Web page elements to separate different contents or focus the user attention on a specific content
Britto and Pizzolato, 2016	Strategy	Avoid automatic page redirects or expiration time for tasks. The user is who should control navigation and time to perform a task
Britto and Pizzolato, 2016	Strategy	Avoid the use of disturbing and explosive sounds, like sirens or fireworks
Britto and Pizzolato, 2016	Strategy	In interactive lessons and educational activities, it is recommended allow up to five attempts before showing the correct answer
Britto and Pizzolato, 2016	Structure	Allow critical actions to be reverted, cancelled, undone or confirmed
Britto and Pizzolato, 2016	Structure	Icons, images and label of menus and actions should be compatible to real world, representing concrete actions and everyday life activities in order to be easily recognized
Britto and Pizzolato, 2016	Structure	Present appropriate instructions to interact with interface elements, provide clear messages about errors and provide mechanisms to solve the errors
Britto and Pizzolato, 2016	Structure	Provide a simplified and consistent navigation between pages, use location and progress indicators and present global navigation buttons (Exit, Back to home page, help) on every page

Author/Study	Web development element	Guideline title
Britto and Pizzolato, 2016	Structure	Provide feedback confirm correct actions or alerting about potential mistakes and use audio, text and images to represent the message, avoiding icons with emotions or facial expressions
Britto and Pizzolato, 2016	Structure	Provide immediate instructions and feedback over a interaction restriction with the system or a certain interface element
Britto and Pizzolato, 2016	Structure	Similar elements and interaction must produce similar, consistent and predictable results
Britto and Pizzolato, 2016	Surface	Colors should not be the only way to deliver content and the contrast between background and objects in foreground must be appropriate to distinguish items and distinct content or relate similar information
Britto and Pizzolato, 2016	Surface	Design simple interfaces, with few elements and which present only the features and content need for the current task to be performed by the user
Darejeh and Singh, 2013	Scope	Avoiding using computer terms and the names that are not familiar to all of users for naming tools
Darejeh and Singh, 2013	scope	Putting customization ability for font, colour and size, especially for elders, children and people with visual impairments
Darejeh and Singh, 2013	scope	Using enough descriptive texts, especially for helping elder and blind people
Darejeh and Singh, 2013	Skeleton	Using appropriate graphical objects like avatar or icons for increasing software attraction, especially for children and also for attracting the attention of people with cognitive problems
Darejeh and Singh, 2013	Skeleton	Using larger components such as large buttons, combo boxes. Furthermore, using bigger icons and fonts for showing key functions of the software
Darejeh and Singh, 2013	Structure	Designing interface such that it does not need investigation for finding tools
Darejeh and Singh, 2013	structure	Eliminating features that could cause unnecessary stress and frustration and reducing software complexity by reducing the number of features available at any given time
Dattolo and Luccio, 2017	Scope	Allow customisation.
Dattolo and Luccio, 2017	scope	Decompose the tasks into simple subtasks.
Dattolo and Luccio, 2017	Scope	Efficiency and availability.
Dattolo and Luccio, 2017	Scope	Make adaptive the interaction with users, considering their interaction history, their preferences, requests, and needs.

Author/Study	Web development element	Guideline title
Dattolo and Luccio, 2017	Scope	Pictures should be copiously used together with redundant representation of information.
Dattolo and Luccio, 2017	scope	The interface should be responsive.
Dattolo and Luccio, 2017	Scope	The language should be simple and precise.
Dattolo and Luccio, 2017	Scope	The text should go with pictures. It should be clear, simple, and short (at most one sentence on a line); should be in a big font (14), in plain Sans-serif style (e.g., Verdana), in a mild color. Headings and titles should be used.
Dattolo and Luccio, 2017	Scope	Try to engage the user.
Dattolo and Luccio, 2017	Skeleton	Add navigation information and navigation buttons at the top and the bottom of the page.
Dattolo and Luccio, 2017	Skeleton	Pictures can be drawings, photographs, symbolic images, should be easy to understand, should not go in the background, should be in a sharp focus.
Dattolo and Luccio, 2017	Strategy	Background sounds, moving text, blinking images and horizontal scrolling should be avoided.
Dattolo and Luccio, 2017	Structure	Acronyms and abbreviations, non-literal text, and jargon should not be used.
Dattolo and Luccio, 2017	Structure	Navigation should be consistent and similar in every page/section.
Dattolo and Luccio, 2017	Structure	The content should be predictable and should provide feedbacks.
Dattolo and Luccio, 2017	Structure	The general design and the structure should be simple, clear and predictable, secondary content that distracts the user should be avoided. The number of features available at any time instant should be limited.
Dattolo and Luccio, 2017	Structure	The number of errors should be limited.
Dattolo and Luccio, 2017	Structure	The website and every mobile applications should have a simple and logical structure. Even the first time, the user should be able to easily navigate inside, and should remember the navigational information even at successive visits or uses.
Friedman and Nelson, 2007	Scope	Check reading level with automated tool.
Friedman and Nelson, 2007	Scope	Provide audio/voice-overs where the words are read aloud.
Friedman and Nelson, 2007	Scope	Provide voice captions (audio files) for text.
Friedman and Nelson, 2007	Scope	Support screen readers. Use alternate text tags.
Friedman and Nelson, 2007	scope	Use clear and simple text.

Author/Study	Web development element	Guideline title
Friedman and Nelson, 2007	Scope	Use numbered lists rather than bullets.
Friedman and Nelson, 2007	scope	Use pictures, icons and symbols along with text.
Friedman and Nelson, 2007	scope	Website customizable, control of: type size, placement of navigation (right, left side) contrast, large print, sound.
Friedman and Nelson, 2007	Skeleton	Maintain white space: Use wide margins.
Friedman and Nelson, 2007	Skeleton	Navigation buttons clear, large, and consistent.
Friedman and Nelson, 2007	Structure	Consistent navigation and design on every page.
Friedman and Nelson, 2007	Structure	Do not right justify text; use ragged edge right hand margins.
Friedman and Nelson, 2007	Structure	Give feedback on a user’s actions (e.g. confirm correct choices, alert users to errors or possible errors).
Friedman and Nelson, 2007	Structure	Uncluttered, simple screen layout.
Friedman and Nelson, 2007	Structure	Use exit, home, help, next page buttons on every page.
Friedman and Nelson, 2007	Structure	Use headings, titles and prompts.
Friedman and Nelson, 2007	Structure	Use navigation methods, i.e. ‘undo’ or ‘back button’ to help user recover when lost.
Friedman and Nelson, 2007	Surface	Support font enlargement forWeb browsers.
Friedman and Nelson, 2007	Surface	Use color for contrast.
Friedman and Nelson, 2007	Surface	Use larger fonts, fonts in minimum 12pt or 14pt.
Friedman and Nelson, 2007	Surface	Use Lower case, no ALL CAPS.
Friedman and Nelson, 2007	Surface	Use with sans serif fonts, such as Arial, Verdana, Helvetica, Tahoma.
Harrold, N., C.T. Tan, and D. Rosser., 2012	scope	Sound
Harrold, N., C.T. Tan, and D. Rosser., 2012	Scope	Text
Harrold, N., C.T. Tan, and D. Rosser., 2012	Strategy	Hardware

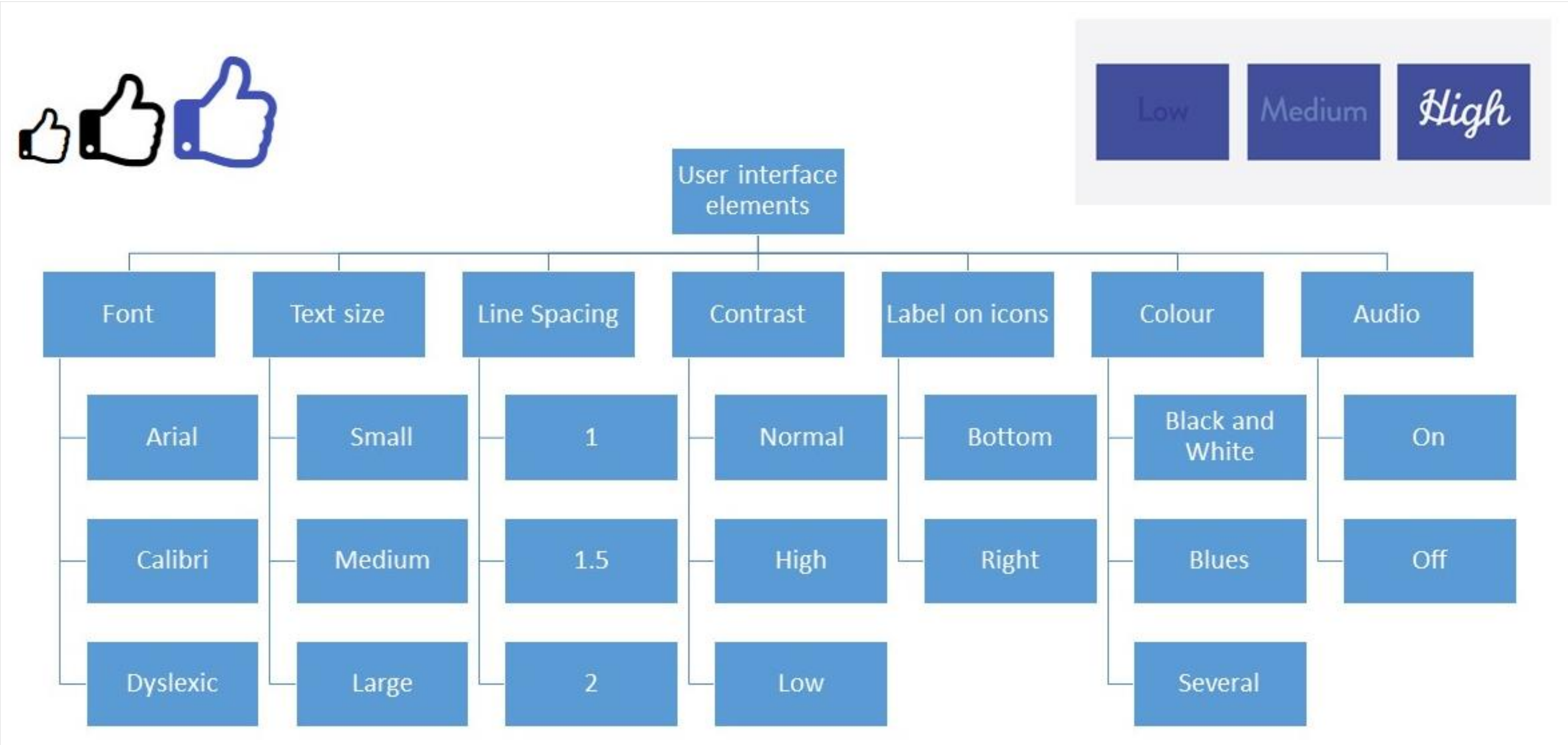
Author/Study	Web development element	Guideline title
Harrold, N., C.T. Tan, and D. Rosser., 2012	Strategy	Repetition
Harrold, N., C.T. Tan, and D. Rosser., 2012	Structure	Anxiety
Harrold, N., C.T. Tan, and D. Rosser., 2012	Structure	Feedback
Harrold, N., C.T. Tan, and D. Rosser., 2012	Structure	Guidance
Harrold, N., C.T. Tan, and D. Rosser., 2012	Structure	Images
Harrold, N., C.T. Tan, and D. Rosser., 2012	Surface	Colours
Hussain, A., et al., 2016	Scope	Admin section
Hussain, A., et al., 2016	Scope	Audio
Hussain, A., et al., 2016	Scope	Evaluating parameter
Hussain, A., et al., 2016	Scope	Language
Hussain, A., et al., 2016	Scope	Picture Exchange Communication System
Hussain, A., et al., 2016	Scope	Pronunciation
Hussain, A., et al., 2016	Scope	Upload photo
Hussain, A., et al., 2016	Skeleton	Icon
Hussain, A., et al., 2016	Skeleton	Number of pictures
Hussain, A., et al., 2016	Skeleton	Screen size
Hussain, A., et al., 2016	Structure	Guide the user through the app
Hussain, A., et al., 2016	Structure	Image life

Author/Study	Web development element	Guideline title
Hussain, A., et al., 2016	Structure	Navigation
Hussain, A., et al., 2016	Structure	User Interface
Hussain, A., et al., 2016	Surface	Colour
Pavlov, 2014	Scope	Allow the use of browser’s buttons.
Pavlov, 2014	Scope	Give short instructions of use at every step
Pavlov, 2014	Scope	Pages should load fast.
Pavlov, 2014	Skeleton	Do not have horizontal scrolling.
Pavlov, 2014	Skeleton	Indicate on each page clearly where the user is.
Pavlov, 2014	Skeleton	Make sure text box is clearly separated from the rest.
Pavlov, 2014	Skeleton	Present text in a single column.
Pavlov, 2014	Skeleton	Use clear, large buttons with both icons and text.
Pavlov, 2014	Skeleton	Use simple graphics.
Pavlov, 2014	Strategy	Use visual indicators for time-consuming actions.
Pavlov, 2014	Structure	Avoid buttons with icons only, except for the most popular actions. For example, “back”.
Pavlov, 2014	Structure	Avoid cluttered interface
Pavlov, 2014	Structure	do not Use complex menus.
Pavlov, 2014	Structure	Have a Help button.
Pavlov, 2014	Structure	Strive for simple, clear navigation.
Pavlov, 2014	Structure	Support navigation with mouse or keyboard.
Pavlov, 2014	Structure	Try to have one toolbar.
Pavlov, 2014	Surface	Design for simplicity and few elements on screen.
Pavlov, 2014	Surface	Do not overlap transparent images and text.

Author/Study	Web development element	Guideline title
Pavlov, 2014	Surface	Do not use bright colors.
Pavlov, 2014	Surface	Do not use many-colored icons.
Pavlov, 2014	Surface	Do not use pop-up elements and distractions.
Pavlov, 2014	Surface	Do not user background images.
Pavlov, 2014	Surface	Font type and size.
Pavlov, 2014	Surface	Line-spacing.
Pavlov, 2014	Surface	No element should stand out too much.
Pavlov, 2014	Surface	Themes for text background and foreground colors.
Pavlov, 2014	Surface	Use clear, sans-serif fonts.
Pavlov, 2014	Surface	Use contrast between font and background.
Pavlov, 2014	Surface	Use soft, mild colors.
Sitdhisanguan, K., et al., 2012	Scope	Use of sound
Sitdhisanguan, K., et al., 2012	Strategy	Learning stimulation
Sitdhisanguan, K., et al., 2012	Structure	Giving a correct answer
Sitdhisanguan, K., et al., 2012	Structure	Incorrect-response feedback
Sitdhisanguan, K., et al., 2012	Surface	Choice of foreground/background color
WCAG (W3C), 2018	Scope	Adaptable
WCAG (W3C), 2018	Scope	Compatible
WCAG (W3C), 2018	Scope	Input Modalities

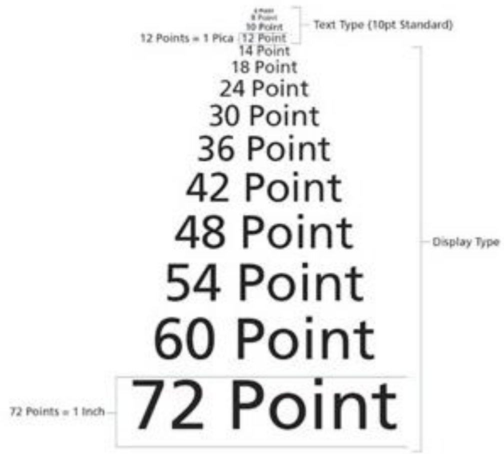
Author/Study	Web development element	Guideline title
WCAG (W3C), 2018	Scope	readable
WCAG (W3C), 2018	Scope	Text Alternatives
WCAG (W3C), 2018	Strategy	Enough Time
WCAG (W3C), 2018	Strategy	Seizures and Physical Reactions
WCAG (W3C), 2018	Strategy	Time-based Media
WCAG (W3C), 2018	Structure	input assistance
WCAG (W3C), 2018	Structure	Keyboard Accessible
WCAG (W3C), 2018	Structure	Navigable
WCAG (W3C), 2018	Structure	predictable
WCAG (W3C), 2018	Surface	Distinguishable

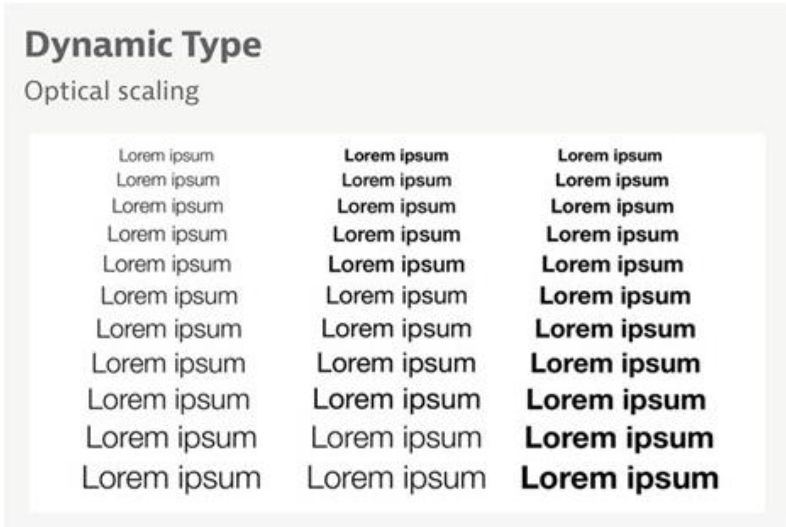
Appendix C User interface elements to be analysed during the focus group

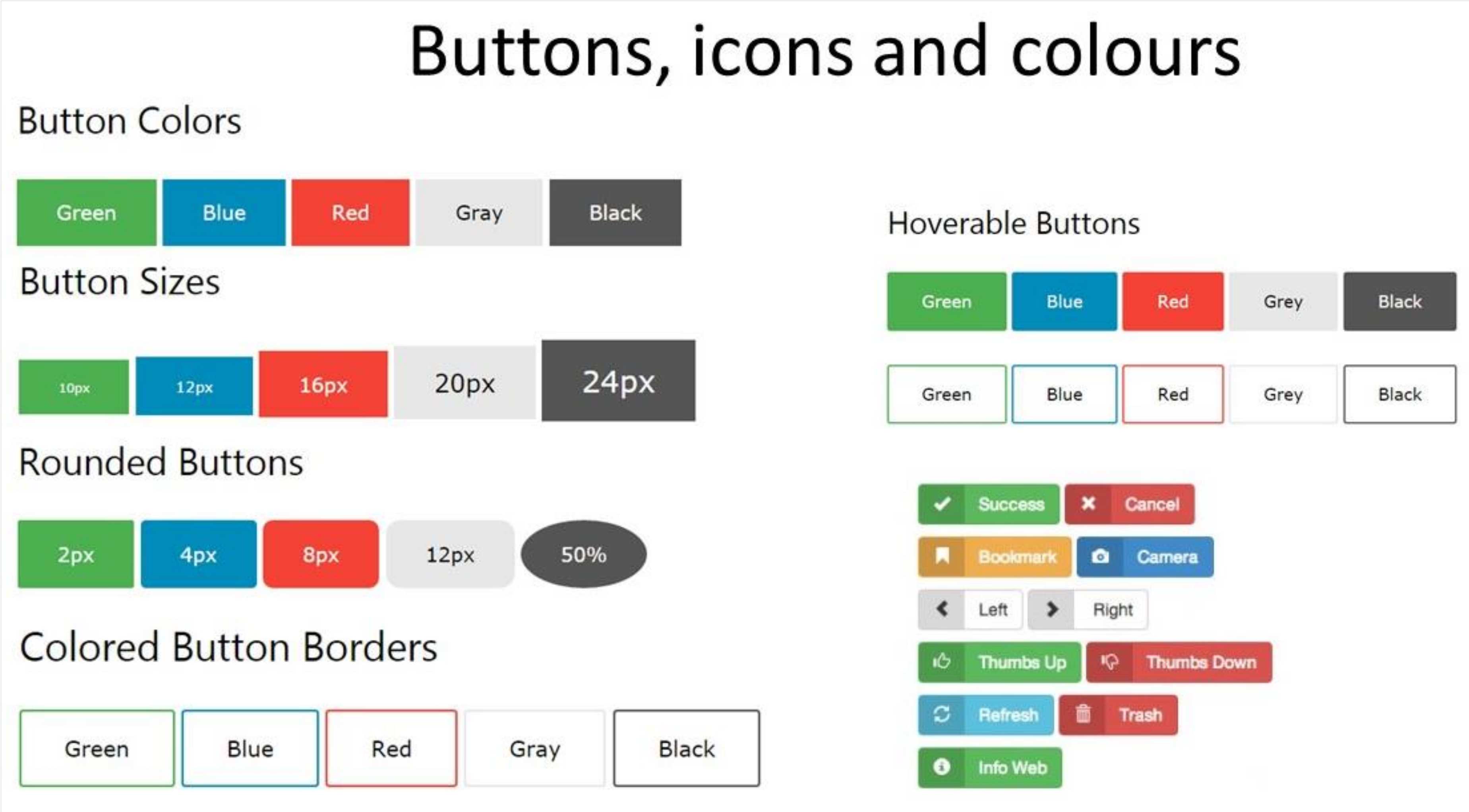


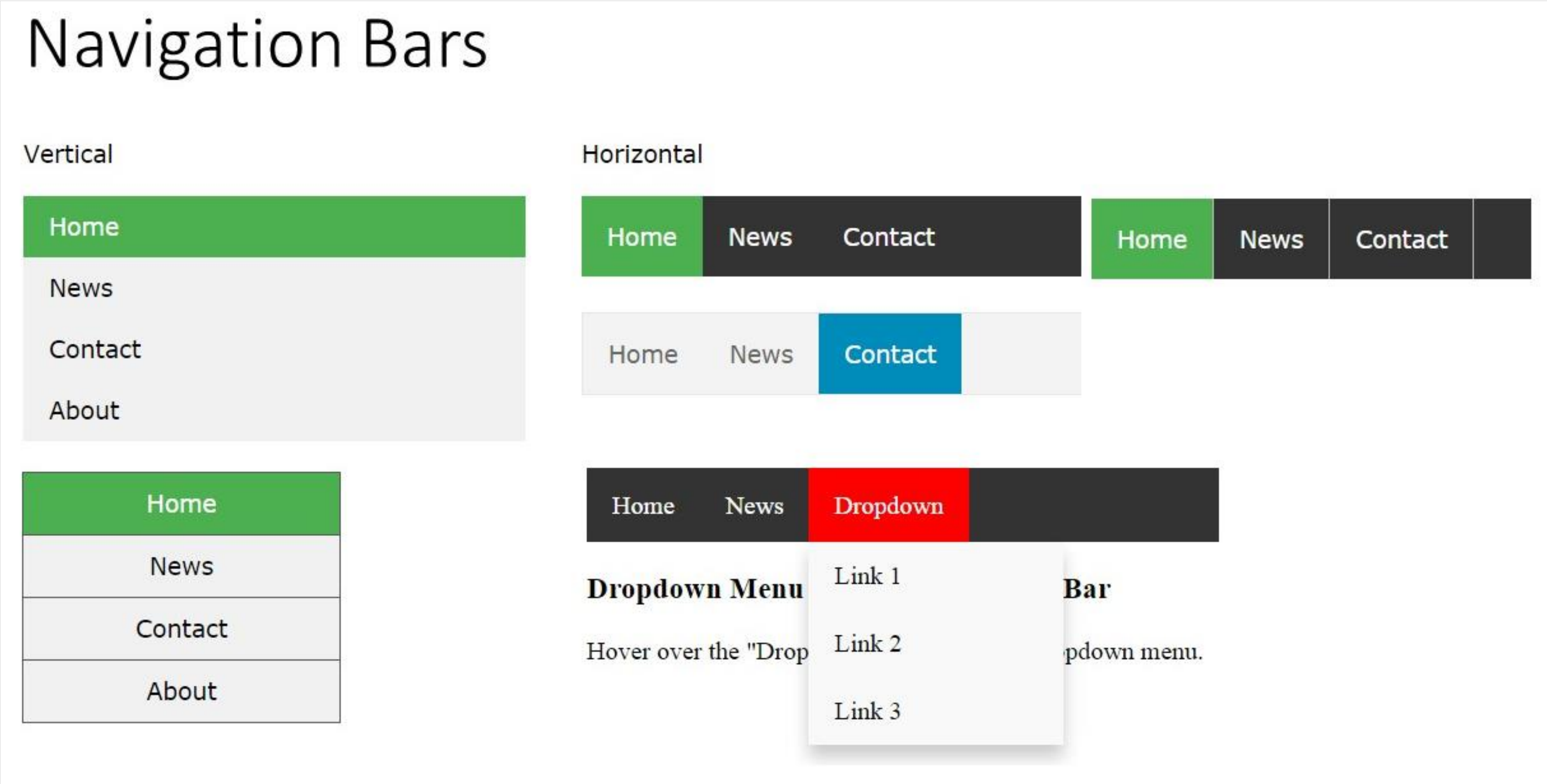
Fonts

Generic family	Font family
Serif	Times New Roman Georgia
Sans-serif	Arial Verdana
Monospace	Courier New Lucida Console






Buttons, icons and colours
Button Colors
Green
Blue
Red
Gray
Black
Button Sizes
10px
12px
16px
20px
24px
Rounded Buttons
2px
4px
8px
12px
50%
Colored Button Borders
Green
Blue
Red
Gray
Black
Hoverable Buttons
Green
Blue
Red
Grey
Black
Green
Blue
Red
Grey
Black
Success
Cancel
Bookmark
Camera
Left
Right
Thumbs Up
Thumbs Down
Refresh
Trash
Info Web


Navigation Bars
Vertical
Home
News
Contact
About
Home
News
Contact
About
Horizontal
Home
News
Contact
Home
News
Contact
Home
News
Contact
Home
News
Dropdown
Link 1
Link 2
Link 3
Dropdown Menu
Bar
Hover over the "Drop
pdown menu.

Appendix D webDesignASD.owl

```
<?xml version="1.0"?>
<rdf:RDF xmlns="http://github.com/clau1228/PhD/webDesignASD.owl"
    xml:base="http://github.com/clau1228/PhD/webDesignASD.owl"
    xmlns:owl="http://www.w3.org/2002/07/owl#"
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:xml="http://www.w3.org/XML/1998/namespace"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
    xmlns:webDesignASD="https://github.com/clau1228/PhD/webDesignASD.owl#"
    xmlns:webDesignASD1="http://github.com/clau1228/PhD/webDesignASD.owl.owl#"
    xmlns:webDesignASD2="http://github.com/clau1228/PhD/webDesignASD.owl#"
    xmlns:GenericOntology="http://www.AccessibleOntology.com/GenericOntology.owl#"
    xmlns:AccessibilityOntology="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#">
    <owl:Ontology rdf:about="http://github.com/clau1228/PhD/webDesignASD">
        <owl:versionInfo xml:lang="en">The webDesignASD ontology was created as part of the PhD thesis by Claudia De Los Rios Perez from Curtin
         University, Perth - Australia. ORCID: 0000-0002-4603-3006 (December 2019)</owl:versionInfo>
    </owl:Ontology>



    <!--
    ///////////////////////////////////////////////////////////////////////////////////////
    //
    // Annotation properties
    //
    ///////////////////////////////////////////////////////////////////////////////////////
    -->

    <!-- http://github.com/clau1228/PhD/webDesignASD.owl#affects -->

    <owl:AnnotationProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD.owl#affects"/>

    <!-- http://github.com/clau1228/PhD/webDesignASD.owl#hasBirthYear -->

    <owl:AnnotationProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD.owl#hasBirthYear"/>

    <!-- http://github.com/clau1228/PhD/webDesignASD.owl#hasGender -->

    <owl:AnnotationProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD.owl#hasGender"/>

    <!-- http://github.com/clau1228/PhD/webDesignASD.owl#hasLocation -->

    <owl:AnnotationProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD.owl#hasLocation"/>
```

```
<!-- http://github.com/clau1228/PhD/webDesignASD.owl#hasPreference -->

<owl:AnnotationProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD.owl#hasPreference"/>

<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#hasDescription -->

<owl:AnnotationProperty rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#hasDescription"/>

<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#hasName -->

<owl:AnnotationProperty rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#hasName"/>



<!--
///////////////////////////////////////////////////////////////////////////////////////
//
// Object Properties
//
///////////////////////////////////////////////////////////////////////////////////////
-->

<!-- http://github.com/clau1228/PhD/webDesignASD#affects -->

<owl:ObjectProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD#affects">
    <owl:inverseOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#isRelatedTo"/>
    <rdfs:domain rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <rdfs:range rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
</owl:ObjectProperty>

<!-- http://github.com/clau1228/PhD/webDesignASD#hasColor -->

<owl:ObjectProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD#hasColor">
    <rdfs:domain rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
    <rdfs:range rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Colour"/>
</owl:ObjectProperty>

<!-- http://github.com/clau1228/PhD/webDesignASD#hasGuideline -->

<owl:ObjectProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD#hasGuideline">
    <owl:inverseOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#isUsedBy"/>
    <rdfs:domain rdf:resource="http://github.com/clau1228/PhD/webDesignASD#AutismProfile"/>
    <rdfs:range rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
</owl:ObjectProperty>
```

```
<!-- http://github.com/clau1228/PhD/webDesignASD#hasPreference -->

<owl:ObjectProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD#hasPreference">
    <owl:inverseOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#isPreferred"/>
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#User"/>
    <rdfs:range rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
    <rdfs:comment xml:lang="en">Preferences about user interfaces elements by the user</rdfs:comment>
</owl:ObjectProperty>

<!-- http://github.com/clau1228/PhD/webDesignASD#isPreferred -->

<owl:ObjectProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD#isPreferred">
    <rdfs:domain rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
    <rdfs:range rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#User"/>
</owl:ObjectProperty>

<!-- http://github.com/clau1228/PhD/webDesignASD#isRelatedTo -->

<owl:ObjectProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD#isRelatedTo">
    <rdfs:domain rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
    <rdfs:range rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
</owl:ObjectProperty>

<!-- http://github.com/clau1228/PhD/webDesignASD#isUsedBy -->

<owl:ObjectProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD#isUsedBy">
    <rdfs:domain rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <rdfs:range rdf:resource="http://github.com/clau1228/PhD/webDesignASD#AutismProfile"/>
</owl:ObjectProperty>

<!-- http://www.AccessibleOntology.com/GenericOntology.owl#associatedWith -->

<owl:ObjectProperty rdf:about="http://www.AccessibleOntology.com/GenericOntology.owl#associatedWith">
    <owl:inverseOf rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#isAffectedBy"/>
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Disability"/>
    <rdfs:range rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#BodyFunction"/>
</owl:ObjectProperty>
```

```
<!-- http://www.AccessibleOntology.com/GenericOntology.owl#belongsTo -->

<owl:ObjectProperty rdf:about="http://www.AccessibleOntology.com/GenericOntology.owl#belongsTo">
    <owl:inverseOf rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#includes"/>
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Disability"/>
    <rdfs:range rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Impairment"/>
</owl:ObjectProperty>

<!-- http://www.AccessibleOntology.com/GenericOntology.owl#hasDisability -->

<owl:ObjectProperty rdf:about="http://www.AccessibleOntology.com/GenericOntology.owl#hasDisability">
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#User"/>
    <rdfs:range rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Disability"/>
</owl:ObjectProperty>

<!-- http://www.AccessibleOntology.com/GenericOntology.owl#includes -->

<owl:ObjectProperty rdf:about="http://www.AccessibleOntology.com/GenericOntology.owl#includes">
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Impairment"/>
    <rdfs:range rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Disability"/>
</owl:ObjectProperty>

<!-- http://www.AccessibleOntology.com/GenericOntology.owl#intendedFor -->

<owl:ObjectProperty rdf:about="http://www.AccessibleOntology.com/GenericOntology.owl#intendedFor">
    <owl:inverseOf rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#needs"/>
    <rdfs:domain rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebAdaptation"/>
    <rdfs:range rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Disability"/>
</owl:ObjectProperty>

<!-- http://www.AccessibleOntology.com/GenericOntology.owl#isAffectedBy -->

<owl:ObjectProperty rdf:about="http://www.AccessibleOntology.com/GenericOntology.owl#isAffectedBy">
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#BodyFunction"/>
    <rdfs:range rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Disability"/>
</owl:ObjectProperty>

<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#hasCapability -->

<owl:ObjectProperty rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#hasCapability">
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#User"/>
    <rdfs:range rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Capability"/>
</owl:ObjectProperty>
```

```
<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#isDueTo -->

<owl:ObjectProperty rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#isDueTo">
    <owl:inverseOf rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#relatedTo"/>
    <rdfs:domain rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Capability"/>
    <rdfs:range rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#BodyFunction"/>
</owl:ObjectProperty>

<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#linksTo -->

<owl:ObjectProperty rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#linksTo">
    <owl:inverseOf rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#requires"/>
    <rdfs:domain rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Capability"/>
    <rdfs:range rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebAdaptation"/>
</owl:ObjectProperty>

<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#needs -->

<owl:ObjectProperty rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#needs">
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Disability"/>
    <rdfs:range rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebAdaptation"/>
</owl:ObjectProperty>

<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#relatedTo -->

<owl:ObjectProperty rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#relatedTo">
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#BodyFunction"/>
    <rdfs:range rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Capability"/>
</owl:ObjectProperty>

<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#requires -->

<owl:ObjectProperty rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#requires">
    <rdfs:domain rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebAdaptation"/>
    <rdfs:range rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Capability"/>
</owl:ObjectProperty>
```

```
<!--
///////////////////////////////////////////////////////////////////////////////////////
//
// Data properties
//
///////////////////////////////////////////////////////////////////////////////////////
-->

<!-- http://github.com/clau1228/PhD/webDesignASD#hasBirthYear -->

<owl:DatatypeProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD#hasBirthYear">
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#User"/>
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#integer"/>
</owl:DatatypeProperty>

<!-- http://github.com/clau1228/PhD/webDesignASD#hasGender -->

<owl:DatatypeProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD#hasGender">
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#User"/>
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
</owl:DatatypeProperty>

<!-- http://github.com/clau1228/PhD/webDesignASD#hasLocation -->

<owl:DatatypeProperty rdf:about="http://github.com/clau1228/PhD/webDesignASD#hasLocation">
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#User"/>
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
</owl:DatatypeProperty>

<!-- http://www.AccessibleOntology.com/GenericOntology.owl#TechnologyUsage -->

<owl:DatatypeProperty rdf:about="http://www.AccessibleOntology.com/GenericOntology.owl#TechnologyUsage">
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#User"/>
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
</owl:DatatypeProperty>

<!-- http://www.AccessibleOntology.com/GenericOntology.owl#hasAge -->

<owl:DatatypeProperty rdf:about="http://www.AccessibleOntology.com/GenericOntology.owl#hasAge">
    <rdfs:domain rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#User"/>
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#int"/>
</owl:DatatypeProperty>
```

```
<!--
///////////////////////////////////////////////////////////////////////////////////////
//
// Classes
//
///////////////////////////////////////////////////////////////////////////////////////
-->

<!-- http://github.com/clau1228/PhD/webDesignASD#Animated -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#Animated">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Image"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#Autism -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#Autism">
    <rdfs:subClassOf rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Disability"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#AutismProfile -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#AutismProfile">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebAdaptation"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#Background -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#Background">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#Black -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#Black">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Colour"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#Button -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#Button">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
</owl:Class>
```

```
<!-- http://github.com/clau1228/PhD/webDesignASD#Colour -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#Colour">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#DobleSpacing -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#DobleSpacing">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Spacing"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#Font -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#Font">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#FontFamily -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#FontFamily">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Font"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#FontSize -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#FontSize">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Font"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#Image -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#Image">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#NormalSpacing -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#NormalSpacing">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Spacing"/>
</owl:Class>
```

```
<!-- http://github.com/clau1228/PhD/webDesignASD#Spacing -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#Spacing">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#Static -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#Static">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Image"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#User01_WebAdaptation -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#User01_WebAdaptation">
    <owl:equivalentClass>
        <owl:Class>
            <owl:intersectionOf rdf:parseType="Collection">
                <rdf:Description rdf:about="http://github.com/clau1228/PhD/webDesignASD#WebAdaptation"/>
                <owl:Restriction>
                    <owl:onProperty rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#intendedFor"/>
                    <owl:hasValue rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
                </owl:Restriction>
                <owl:Restriction>
                    <owl:onProperty rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#requires"/>
                    <owl:hasValue
                     rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Good_Visual_Capability"/>
                </owl:Restriction>
            </owl:intersectionOf>
        </owl:Class>
    </owl:equivalentClass>
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebAdaptation"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebAdaptation"/>
</owl:Class>
```

```
<!-- http://github.com/clau1228/PhD/webDesignASD#WebAdaptation -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#WebAdaptation">
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#intendedFor"/>
            <owl:someValuesFrom rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Disability"/>
        </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#requires"/>
            <owl:someValuesFrom rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Capability"/>
        </owl:Restriction>
    </rdfs:subClassOf>
    <AccessibilityOntology:hasDescription xml:lang="en">Web adaptations are the user interface elements that require to be adapted to improve
     the web experience and web accessibility for people on the autism spectrum.</AccessibilityOntology:hasDescription>
    <AccessibilityOntology:hasName xml:lang="en">WebAdaptation</AccessibilityOntology:hasName>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebAdaptation"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#White -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#White">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Colour"/>
</owl:Class>

<!-- http://github.com/clau1228/PhD/webDesignASD#1.5Lines -->

<owl:Class rdf:about="http://github.com/clau1228/PhD/webDesignASD#1.5Lines">
    <rdfs:subClassOf rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Spacing"/>
</owl:Class>
```

```
<!-- http://www.AccessibleOntology.com/GenericOntology.owl#BodyFunction -->

<owl:Class rdf:about="http://www.AccessibleOntology.com/GenericOntology.owl#BodyFunction">
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#isAffectedBy"/>
            <owl:someValuesFrom rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Disability"/>
        </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#relatedTo"/>
            <owl:someValuesFrom rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Capability"/>
        </owl:Restriction>
    </rdfs:subClassOf>
    <AccessibilityOntology:hasDescription xml:lang="en">Body functions are the physiological functions of body systems (including psychological
     functions), each Disability has a group of body functions that could be affected by it.</AccessibilityOntology:hasDescription>
    <AccessibilityOntology:hasName xml:lang="en">BodyFunction</AccessibilityOntology:hasName>
</owl:Class>

<!-- http://www.AccessibleOntology.com/GenericOntology.owl#Disability -->

<owl:Class rdf:about="http://www.AccessibleOntology.com/GenericOntology.owl#Disability">
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#associatedWith"/>
            <owl:someValuesFrom rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#BodyFunction"/>
        </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#belongsTo"/>
            <owl:someValuesFrom rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Impairment"/>
        </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#needs"/>
            <owl:someValuesFrom rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebAdaptation"/>
        </owl:Restriction>
    </rdfs:subClassOf>
    <AccessibilityOntology:hasDescription xml:lang="en">Disability is part of the human condition.  Almost everyone will be temporarily or
     permanently impaired at some point in life, and those who survive to old age will experience increasing difficulties in functioning”
     (World Health Organization - WHO, 2011). Disabilities are grouped by impairments.</AccessibilityOntology:hasDescription>
    <AccessibilityOntology:hasName xml:lang="en">Disability</AccessibilityOntology:hasName>
</owl:Class>
```

```
<!-- http://www.AccessibleOntology.com/GenericOntology.owl#Impairment -->

<owl:Class rdf:about="http://www.AccessibleOntology.com/GenericOntology.owl#Impairment">
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#includes"/>
            <owl:someValuesFrom rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Disability"/>
        </owl:Restriction>
    </rdfs:subClassOf>
    <AccessibilityOntology:hasDescription xml:lang="en">Impairments are problems in body function or structure such as a significant deviation
     or loss, can be temporary or permanent; progressive, regressive or static; intermittent or continuous" (World Health Organization,
     2007).</AccessibilityOntology:hasDescription>
    <AccessibilityOntology:hasName xml:lang="en">Impairment</AccessibilityOntology:hasName>
</owl:Class>

<!-- http://www.AccessibleOntology.com/GenericOntology.owl#User -->

<owl:Class rdf:about="http://www.AccessibleOntology.com/GenericOntology.owl#User">
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#hasDisability"/>
            <owl:someValuesFrom rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Disability"/>
        </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#hasCapability"/>
            <owl:someValuesFrom rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Capability"/>
        </owl:Restriction>
    </rdfs:subClassOf>
    <AccessibilityOntology:hasDescription xml:lang="en">Describes personas with disabilities and
     capabilities.</AccessibilityOntology:hasDescription>
    <AccessibilityOntology:hasName xml:lang="en">User</AccessibilityOntology:hasName>
</owl:Class>
```

```xml
<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Capability -->

<owl:Class rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Capability">
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#isDueTo"/>
            <owl:someValuesFrom rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#BodyFunction"/>
        </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#linksTo"/>
            <owl:someValuesFrom rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebAdaptation"/>
        </owl:Restriction>
    </rdfs:subClassOf>
    <AccessibilityOntology:hasDescription xml:lang="en">User’s capabilities regardless of the user’s disabilities, with respect to the use of
     support assistance. E.g., Braille literacy skill, can feel small vibrations, can move hand well, etc. Independently of their disabilities,
     users can develop specific capabilities or skills.</AccessibilityOntology:hasDescription>
    <AccessibilityOntology:hasName xml:lang="en">Capability</AccessibilityOntology:hasName>
</owl:Class>

<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#QualityOfVision -->

<owl:Class rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#QualityOfVision">
    <rdfs:subClassOf rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#SeeingFunction"/>
</owl:Class>

<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#SeeingFunction -->

<owl:Class rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#SeeingFunction">
    <rdfs:subClassOf rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#SensoryFunction"/>
</owl:Class>

<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#SensorialCapability -->

<owl:Class rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#SensorialCapability">
    <rdfs:subClassOf rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Capability"/>
</owl:Class>

<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#SensoryFunction -->

<owl:Class rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#SensoryFunction">
    <rdfs:subClassOf rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#BodyFunction"/>
</owl:Class>
```

```xml
<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Typing -->

<owl:Class rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Typing">
    <rdfs:subClassOf rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#WriteCapable"/>
</owl:Class>

<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#VisualCapability -->

<owl:Class rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#VisualCapability">
    <rdfs:subClassOf rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#SensorialCapability"/>
</owl:Class>

<!-- http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#WriteCapable -->

<owl:Class rdf:about="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#WriteCapable">
    <rdfs:subClassOf rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Capability"/>
</owl:Class>



<!--
///////////////////////////////////////////////////////////////////////////////////////
//
// Individuals
//
///////////////////////////////////////////////////////////////////////////////////////
-->

<!-- http://github.com/clau1228/PhD/webDesignASD#Allow_customizations_according_to_user_preferences -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Allow_customizations_according_to_user_preferences">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <AccessibilityOntology:hasName>Allow customizations according to user preferences</AccessibilityOntology:hasName>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#AnimatedImage -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#AnimatedImage">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Animated"/>
</owl:NamedIndividual>
```

```
<!-- http://github.com/clau1228/PhD/webDesignASD#Arial_font -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Arial_font">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#FontFamily"/>
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#AutisticProfile -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#AutisticProfile">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#AutismProfile"/>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Avoid_the_use_of_moving_elements -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Avoid_the_use_of_moving_elements">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <webDesignASD2:affects rdf:resource="http://github.com/clau1228/PhD/webDesignASD#StaticImage"/>
    <AccessibilityOntology:hasName>Avoid the use of moving elements</AccessibilityOntology:hasName>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Avoid_too_many_distracting_elements_and_colours -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Avoid_too_many_distracting_elements_and_colours">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <AccessibilityOntology:hasName>Avoid too many distracting elements and colours</AccessibilityOntology:hasName>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Black_background -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Black_background">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Background"/>
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Black_font -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Black_font">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
</owl:NamedIndividual>
```

```xml
<!-- http://github.com/clau1228/PhD/webDesignASD#Design_for_simplicity_and_consistency_allowing_focus_and_attention -->

<owl:NamedIndividual
 rdf:about="http://github.com/clau1228/PhD/webDesignASD#Design_for_simplicity_and_consistency_allowing_focus_and_attention">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <AccessibilityOntology:hasName>Design for simplicity and consistency allowing focus and attention</AccessibilityOntology:hasName>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Dyslexia -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Dyslexia">
    <rdf:type rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Disability"/>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Dyslexic_font -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Dyslexic_font">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#FontFamily"/>
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
    <GenericOntology:intendedFor rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Dyslexia"/>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Gray_background -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Gray_background">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Background"/>
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Gray_font -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Gray_font">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Include_help_and_errors_feedback -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Include_help_and_errors_feedback">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <AccessibilityOntology:hasName>Include help and errors feedback</AccessibilityOntology:hasName>
</owl:NamedIndividual>
```

```
<!-- http://github.com/clau1228/PhD/webDesignASD#Large_font -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Large_font">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#FontSize"/>
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
    <GenericOntology:intendedFor
     rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Poor_Visual_Capability"/>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Medium_font -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Medium_font">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#FontSize"/>
    <AccessibilityOntology:requires
     rdf:resource="http://www.semanticweb.org/brunil/ontologies/2017/1/AccessibilityOntology.owl#Good_Visual_Capability"/>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Provide_enough_time_on_general_tasks -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Provide_enough_time_on_general_tasks">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <AccessibilityOntology:hasName>Provide enough time on general tasks</AccessibilityOntology:hasName>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Provide_multiple_source_of_information -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Provide_multiple_source_of_information">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <AccessibilityOntology:hasName>Provide multiple source of information</AccessibilityOntology:hasName>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Provide_simplicity_and_consistency_during_navigation -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Provide_simplicity_and_consistency_during_navigation">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <AccessibilityOntology:hasName>Provide simplicity and consistency during navigation</AccessibilityOntology:hasName>
</owl:NamedIndividual>
```

```
<!-- http://github.com/clau1228/PhD/webDesignASD#Readable_text -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Readable_text">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <AccessibilityOntology:hasDescription xml:lang="en">A text is readable is a user with grade 7 or better can read and can understand the
     text.</AccessibilityOntology:hasDescription>
    <AccessibilityOntology:hasName xml:lang="en">Readable text</AccessibilityOntology:hasName>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Small_font -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Small_font">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#FontSize"/>
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#UserInterfaceElement"/>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#StaticImage -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#StaticImage">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Static"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Use_a_colour_contrast_that_facilitates_understanding -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Use_a_colour_contrast_that_facilitates_understanding">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <AccessibilityOntology:hasName>Use a colour contrast that facilitates understanding</AccessibilityOntology:hasName>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Use_enough_spacing_and_size_between_the_different_user_interface_elements -->

<owl:NamedIndividual
 rdf:about="http://github.com/clau1228/PhD/webDesignASD#Use_enough_spacing_and_size_between_the_different_user_interface_elements">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <AccessibilityOntology:hasName>Use enough spacing and size between the different user interface elements</AccessibilityOntology:hasName>
</owl:NamedIndividual>
```

```xml
<!-- http://github.com/clau1228/PhD/webDesignASD#Use_literals_and_concrete_actions_language -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Use_literals_and_concrete_actions_language">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <AccessibilityOntology:hasName>Use literals and concrete actions language</AccessibilityOntology:hasName>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Use_simple_graphic_elements -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Use_simple_graphic_elements">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <AccessibilityOntology:hasName>Use simple graphic elements</AccessibilityOntology:hasName>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#Use_simple_language_facilitating_readability -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#Use_simple_language_facilitating_readability">
    <rdf:type rdf:resource="http://github.com/clau1228/PhD/webDesignASD#WebDesignGuideline"/>
    <GenericOntology:intendedFor rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <webDesignASD2:affects rdf:resource="http://github.com/clau1228/PhD/webDesignASD#Readable_text"/>
    <AccessibilityOntology:hasName>Use simple language facilitating readability</AccessibilityOntology:hasName>
</owl:NamedIndividual>

<!-- http://github.com/clau1228/PhD/webDesignASD#User_01 -->

<owl:NamedIndividual rdf:about="http://github.com/clau1228/PhD/webDesignASD#User_01">
    <rdf:type rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#User"/>
    <GenericOntology:hasDisability rdf:resource="http://www.AccessibleOntology.com/GenericOntology.owl#Autism"/>
    <AccessibilityOntology:hasCapability
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```
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<!-- Generated by the OWL API (version 4.5.9.2019-02-01T07:24:44Z) https://github.com/owlcs/owlapi -->
```

Appendix E Survey

Welcome

Welcome to this research study.

We are interested in understanding user interfaces for transportation purposes. You will be presented with information relevant to transportation and asked to answer some questions about it. Please be assured that your responses will be kept completely confidential.

The study has two parts that should take you around 10 minutes each to complete, and finalizing you will receive an incentive for your participation.

Part 1: Survey about transportation preferences

Part 2: Tasks on four different transportation websites. (Eye tracking evaluation) I have received information regarding this research and had an opportunity to ask questions. I believe I understand the purpose, extent and possible risks of my involvement in this project and I voluntarily consent to take part.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2017-0621). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au

○ I understand this project and I would like to take part in it. Please select this option and click next to continue.

Registration

Please fill your information:

○ My study ID is: ____

Page 1 of 14

Section 1: General questions about transportation preferences and tools

At the end of this section, you will be asked to inform the interviewer.

What is your main mode of transportation for your daily commute?

- ◯ I mainly use public transport.
- ◯ I mainly rely on someone else to be transported.
- ◯ I mainly drive a car or motor vehicle.
- ◯ I mainly use my bicycle.
- ◯ I mainly walk.
- ◯ Other, please specify: ______________________________

What is your favourite form of transportation?

- ◯ Public transport
- ◯ To rely on someone else to be transported.
- ◯ To drive a particular vehicle.
- ◯ Bicycle
- ◯ To walk
- ◯ Other, please specify: ______________________________

In your personal experience, what is the most unsafe form of transportation?

- ◯ Public transport
- ◯ To rely on someone else to be transported.
- ◯ To drive a particular vehicle.
- ◯ Bicycle
- ◯ To walk
- ◯ Other, please specify: ______________________________

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How often do you use the following tools to plan and do your commute?

	Always (Every day)	Most of the time (2-3 times per week)	About half the time (Once a week)	Sometimes (Twice a month)	Never
Google Maps	○	○	○	○	○
Apple Maps	○	○	○	○	○
Bing Maps	○	○	○	○	○
Waze	○	○	○	○	○
Local website/app (e.g. Transperth)	○	○	○	○	○
Printed map	○	○	○	○	○

Is there any other mobile application or websites that you use for your transportation?

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Which device do you usually use to plan your commute?

- ○ Mobile phone
- ○ Computer
- ○ Tablet
- ○ Other, please specify: ____

Page 3 of 14

If you are in an unknown place, outside your hometown, which would be your first choice to plan your commute?

- ◯ Transport planning App
- ◯ Transport planning website
- ◯ Printed maps
- ◯ Asking someone for advice
- ◯ Follow signage and find my way
- ◯ Other, please specify: ______________________________

Do you use any intelligent personal assistant for planning or executing your transportation? What is your experience using them? E.g. Google Assistant, Apple Siri, Microsoft Cortana, Amazon Alexa.

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End of this section, please inform the interviewer.

Section 2: General questions about Website # 1.

At the end of this section, you will be asked to inform the interviewer.

Website # 1

Based on your knowledge and experience in the first website, please select one option for each statement:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
The website is easy and intuitive to use	○	○	○	○	○
The website is confusing	○	○	○	○	○
The website has a pleasing color, font and spacing scheme	○	○	○	○	○
It is easy to find the information I need	○	○	○	○	○
The website annoys me	○	○	○	○	○
It took me less time than I expected to find the information I was looking for	○	○	○	○	○
It is easy to understand the information presented in the website	○	○	○	○	○
I would recommend this website to a friend or colleague	○	○	○	○	○
In general, I am satisfied with this website	○	○	○	○	○

Page 5 of 14

Please review the website with a score out of 10.

Why have you given this score?

End of this section, please inform the interviewer.

Section 3: General questions about Website # 2

At the end of this section, you will be asked to inform the interviewer.

Website # 2

Based on your knowledge and experience in the second website, please select one option for each statement:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
The website is easy and intuitive to use	○	○	○	○	○
The website is confusing	○	○	○	○	○
The website has a pleasing color, font and spacing scheme	○	○	○	○	○
It is easy to find the information I need	○	○	○	○	○
The website annoys me	○	○	○	○	○
It took me less time than I expected to find the information I was looking for	○	○	○	○	○
It is easy to understand the information presented in the website	○	○	○	○	○
I would recommend this website to a friend or colleague	○	○	○	○	○
In general, I am satisfied with this website	○	○	○	○	○

Page 7 of 14

Please review the website with a score out of 10.

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Why have you given this score?

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End of this section, please inform the interviewer.

Section 4: General questions about Website # 3

At the end of this section, you will be asked to inform the interviewer.

Website # 3

Based on your knowledge and experience in the third website, please select one option for each statement:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
The website is easy and intuitive to use	○	○	○	○	○
The website is confusing	○	○	○	○	○
The website has a pleasing color, font and spacing scheme	○	○	○	○	○
It is easy to find the information I need	○	○	○	○	○
The website annoys me	○	○	○	○	○
It took me less time than I expected to find the information I was looking for	○	○	○	○	○
It is easy to understand the information presented in the website	○	○	○	○	○
I would recommend this website to a friend or colleague	○	○	○	○	○
In general, I am satisfied with this website	○	○	○	○	○

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Please review the website with a score out of 10.

Why have you given this score?

End of this section, please inform the interviewer.

Section 5: General questions about Website # 4

At the end of this section, you will be asked to inform the interviewer.

Website # 4

Based on your knowledge and experience in the fourth website, please select one option for each statement:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
The website is easy and intuitive to use	○	○	○	○	○
The website is confusing	○	○	○	○	○
The website has a pleasing color, font and spacing scheme	○	○	○	○	○
It is easy to find the information I need	○	○	○	○	○
The website annoys me	○	○	○	○	○
It took me less time than I expected to find the information I was looking for	○	○	○	○	○
It is easy to understand the information presented in the website	○	○	○	○	○
I would recommend this website to a friend or colleague	○	○	○	○	○
In general, I am satisfied with this website	○	○	○	○	○

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Please review the website with a score out of 10.

Why have you given this score?

End of this section, please inform the interviewer.

Last section: General questions comparing the websites

Please answer the following questions based on your experience with the websites:

	Website # 1	Website # 2	Website # 3	Website # 4
Which website would you prefer to use?	○	○	○	○
Which website was more complex to understand?	○	○	○	○
Which website was the easiest to use?	○	○	○	○
Which website provides more tools for personalisations?	○	○	○	○

Are there any features/functionalities from the adaptable website that you would like to see in the other websites?

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Which features of a transportation website are most important to you?

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Which features of a transportation website are least important to you?

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If you could change one thing about the transport websites, what would it be and why?

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Please list the most annoying problems you have had using websites and apps:

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____
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One last question:

Have you participated in another study related with transportation at Curtin University?
(e.g. Mortaza Public transport App, Driving trials)

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Which features of a transportation website are least important to you?

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If you could change one thing about the transport websites, what would it be and why?

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Please list the most annoying problems you have had using websites and apps:

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One more last question:

Have you participated in another study related with transportation at Curtin University?
(e.g. Mortaza Public transport App, Driving trials)

____

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