|  |  |
| --- | --- |
| **Neurodivergent Communication Web App** | |
|  | |
| **COMP30151/52**  **Final Year Project** | **Emma Harris N0987943** |

Table of Contents

[Figures 3](#_Toc165033805)

[INTRODUCTION 4](#_Toc165033806)

[What is Autism and how will this affect decisions made? 4](#_Toc165033807)

[Sensory Processing Disorder 4](#_Toc165033808)

[Nonverbal Episodes 4](#_Toc165033809)

[What are Communication Assistance apps? 5](#_Toc165033810)

[Leloo AAC – Autism Speech App 5](#_Toc165033811)

[Speech Blubs 5](#_Toc165033812)

[Overall 5](#_Toc165033813)

[CONTEXT 5](#_Toc165033814)

[Autism Accessible UI 5](#_Toc165033815)

[Accessible Technology 5](#_Toc165033816)

[Educational Technology 6](#_Toc165033817)

[NEW IDEAS 6](#_Toc165033818)

[Aims and objectives 6](#_Toc165033819)

[Tasks and deliverables 6](#_Toc165033820)

[Resources 7](#_Toc165033821)

[Interview with stakeholders. 7](#_Toc165033822)

[Existing Applications 7](#_Toc165033823)

[Autism websites and journals 7](#_Toc165033824)

[Risks 8](#_Toc165033825)

[Requirements (Before Interviews) 8](#_Toc165033826)

[Functional Requirements Table 8](#_Toc165033827)

[Non-Functional Requirements Table 9](#_Toc165033828)

[Interviewee Requirements 9](#_Toc165033829)

[Interviewee 1 9](#_Toc165033830)

[Interviewee 2 9](#_Toc165033831)

[Interviewee 3 10](#_Toc165033832)

[IMPLEMENTATION 10](#_Toc165033833)

[Choices 10](#_Toc165033834)

[Justifications 12](#_Toc165033835)

[Asp.net framework 12](#_Toc165033836)

[Razor Pages 13](#_Toc165033837)

[Microsoft Copilot 13](#_Toc165033838)

[RESULTS AND DISCUSSION 14](#_Toc165033839)

[Unit Testing 14](#_Toc165033840)

[Integration Testing 15](#_Toc165033841)

[System Testing 15](#_Toc165033842)

[User Acceptance Testing 15](#_Toc165033843)

[Test Implementation 16](#_Toc165033844)

[First Test Iteration 16](#_Toc165033845)

[Second Test Iteration 16](#_Toc165033846)

[Third Test Iteration 16](#_Toc165033847)

[Fourth Test Iteration (UAT) 17](#_Toc165033848)

[CONCLUSIONS AND FUTURE WORK 17](#_Toc165033849)

[Legal, Social, Ethical and Professional Issues (LSEPIs) 17](#_Toc165033850)

[Data Protection Act 17](#_Toc165033851)

[Disability Discrimination Act 17](#_Toc165033852)

[Interview Permission 18](#_Toc165033853)

# Figures

[Figure 1 - Project Timeline 12](#_Toc165547593)

[Figure 2 - First home page design. 15](#_Toc165547594)

[Figure 3 - Second home page design. 15](#_Toc165547595)

[Figure 4 - Third home page design. 16](#_Toc165547596)

[Figure 5 - Fourth home page design. 16](#_Toc165547597)

[Figure 6 - Fifth home page design. 17](#_Toc165547598)

[Figure 7 - Final home page design. 17](#_Toc165547599)

[Figure 8 - Register and Login page before customisation. 18](#_Toc165547600)

[Figure 9 - Register and Login page after customisation. 18](#_Toc165547601)

[Figure 10 - Automated test for emotion buttons 27](#_Toc165547602)

INTRODUCTION

I am going to create a communication app for autistic people to alleviate anxiety and stigma towards issues they face every day. As a person with autism, resources to help with our issues are extremely focused on children and assistance for adults is very uncommon.

## What is Autism and how will this affect decisions made?

Autism spectrum disorder (ASD) is a developmental disability that can cause significant social, communication and behavioural challenges (*What is autism spectrum disorder?* 2022).

“Children with ASD tend to have strong visual processing skills” (Althaus, de Sonneville, Minderaa, Hensen, & Til, 1996; Shah & Frith, 1993; Thaut, 1987).

Visual processing has been extensively studied in individuals with ASD. Research suggests that autistic individuals often exhibit both strengths and weaknesses in visual processing skills.

One aspect where autistic individuals often excel is in detail-oriented processing. Studies have shown that they tend to focus more on local features rather than global configurations compared to neurotypical individuals (Happé & Frith, 2006). This hyper-focused attention to detail can manifest in exceptional abilities, such as in tasks requiring pattern recognition or visual search (Plaisted et al., 1999).

Conversely, difficulties may arise in tasks requiring the integration of visual information. Autistic individuals may struggle with tasks involving gestalt perception, facial recognition, or understanding emotional expressions (Behrmann et al., 2006). These challenges may be attributed to differences in neural connectivity and processing styles (Kaiser et al., 2010).

Moreover, sensory sensitivities are common in autism, and visual processing may be affected by hypersensitivities to certain visual stimuli (Robertson & Baron-Cohen, 2017). For instance, individuals with ASD may experience discomfort or distress in response to bright lights, specific colours, or visual clutter, which can impact their visual processing abilities. Understanding the nuances of visual processing in autism is essential for developing tailored interventions and educational strategies to support individuals with ASD. By capitalizing on strengths while addressing challenges, it is possible to optimize learning and enhance the quality of life for autistic individuals. Therefore, my proposed solution will be image-based, to take advantage of what autistic individuals are naturally more comfortable with.

CDC (2023) states that individuals with autism have restricted/repetitive behaviours or interests, which can manifest as an obsession with routine and control of situations. Hence, it is essential while creating my application since there must be comprehensive customization choices. Autistic individuals also may exhibit inattentive or impulsive behaviour, which must be addressed in the application through engaging stimuli and signposting, to ensure that all relevant information is obtained and used effectively. The learning difficulties associated with this type of developmental disorder will also heavily influence the way my application will be scaffolded, including detailed explanations of all features alongside relevant images to ensure no communication issues. Additionally, the resources or information must be easily and readily available, using a help button or something similar, at any moment if a user forgets where to find them or needs to access them urgently. Having such resources at hand can prevent any delays or confusion and ensure smooth functioning and productivity.

These are some usual challenges that occur and how I will address them in my design:

Sensory Processing Disorder

Sensory processing disorder (SPD) is a condition characterized by difficulties in processing sensory information, leading to atypical responses to sensory stimuli. In autistic individuals, sensory processing issues are common and can significantly impact daily functioning.

1. Definition of Sensory Processing Disorder (SPD):
   1. Sensory processing disorder involves challenges in efficiently organizing and responding to sensory input, including auditory, visual, tactile, olfactory, gustatory, proprioceptive, and vestibular stimuli (Miller et al., 2007).
   2. Sensory processing issues can manifest as hypersensitivity (over-responsiveness) or hyposensitivity (under-responsiveness) to sensory input, as well as difficulties with sensory discrimination and modulation (Bogdashina, 2003).
2. Prevalence of Sensory Processing Issues in Autism:
   1. Sensory processing issues are highly prevalent in individuals with autism spectrum disorder (ASD), with estimates suggesting that up to 90% of autistic individuals experience sensory abnormalities (Leekam et al., 2007; Ben-Sasson et al., 2009).
   2. Autistic individuals may exhibit heightened sensitivities to certain sensory stimuli, such as loud noises, bright lights, textures, or smells, leading to avoidance or distress (Green & Ben-Sasson, 2010).
3. Impact on Daily Functioning:
   1. Sensory processing difficulties can significantly impact various aspects of daily life for autistic individuals, including social interactions, communication, academic performance, and self-regulation (Tomchek & Dunn, 2007).
   2. Challenges with sensory processing may contribute to behavioural difficulties, anxiety, and sensory-related meltdowns or shutdowns in autistic individuals (Mazurek et al., 2013).
4. Neurobiological Underpinnings:
   1. Neuroimaging studies have revealed differences in brain structure and function associated with sensory processing differences in autistic individuals, including alterations in sensory-related brain regions and atypical neural responses to sensory stimuli (Marco et al., 2011; Green et al., 2013).
5. Interventions and Support:
   1. Occupational therapy interventions focusing on sensory integration techniques are commonly used to address sensory processing issues in autistic individuals, aiming to improve sensory regulation, adaptive behaviours, and participation in daily activities (Case-Smith & Arbesman, 2008).
   2. Environmental modifications, sensory accommodations, and sensory-based interventions tailored to individual sensory profiles are also recommended to support autistic individuals in managing sensory challenges (Ausderau et al., 2016).

I will focus on creating a comfortable environment for vulnerable users as I want all people to feel safe and included while using the product.

Nonverbal Episodes

Non-verbal episodes, often prevalent among individuals with autism spectrum disorder (ASD), pose significant challenges in communication. Research indicates that a substantial proportion of individuals with ASD experience difficulties in verbal communication, with approximately 25% to 30% remaining nonverbal throughout their lives (Anderson et al., 2007). This limited verbal communication can range from delayed speech development to a complete absence of speech. Consequently, individuals with ASD may struggle to express their needs, thoughts, and emotions verbally, impacting their social interactions and relationships.

To address communication challenges, non-verbal individuals with ASD often rely on alternative communication methods, such as gestures, picture exchange systems, or augmentative and alternative communication (AAC) devices (Kasari et al., 2014). These alternative methods provide avenues for individuals with ASD to communicate effectively, express their preferences, and engage in social interactions. Research demonstrates the effectiveness of AAC interventions in improving communication skills among non-verbal individuals with ASD.

The inability to communicate verbally may contribute to social isolation, anxiety, and frustration in individuals with ASD. Communication difficulties have been found to significantly impact social functioning and outcomes in this population (Howlin et al., 2004). Moreover, sensory processing differences, commonly observed in individuals with ASD, can further exacerbate communication challenges. Sensory sensitivities or sensory overload may lead to withdrawal, meltdowns, or other non-verbal behaviours that hinder communication (Green et al., 2012).

In summary, non-verbal episodes in individuals with ASD are complex and multifaceted, encompassing challenges in verbal communication, reliance on alternative communication methods, social interaction difficulties, and sensory processing differences. Understanding and addressing these factors are essential for supporting the communication and overall well-being of individuals with ASD.

Using images to help show these feelings and needs without using energy for communication is vital for surviving as an autistic person living day to day.

## Sensory Overload

## Facial Processing

## What are Communication Assistance apps?

### Leloo AAC – Autism Speech App

Pros:

* Friendly Colours (Pastels).
* Text-to-speech features.

Cons:

* Oriented towards children (Many reviews state this problem).
* Most features are locked behind a paywall which should not be the case for something differently-abled people need in daily life.
* Separated areas for “Parents”.

### Speech Blubs

Pros:

* Friendly Animal Characters.
* Activities to help with stress.
* Links to helpful information.

Cons:

* Oriented towards children.
* Separated areas for “Parents”.
* Bright and stressful colours.
* Subscription paywall.

## Overall

I experience intense anxiety in a variety of situations (e.g., University Life, Social life etc.), many of which I do not want to avoid. However, due to my disability, I have avoided these situations as I have no way of having the breaks or exit strategies I require, without coming across as rude. My proposed solution would give people like me a way to explain my disability in a quick, accessible way even when experiencing heightened anxiety.

Another issue I will address is the inability to communicate when having sensory overload. This will include ways to express needs such as food or drink which autistic individuals struggle with independently when in this state. This is an issue that can apply to people of any age, which is important to me as an autistic adult.

CONTEXT

## Autism Accessible UI

Aguiar et al. (2020) emphasize the importance of customizability in an app focused on autistic people due to the drastic differences between the particularities and needs of users. Supported by Liu et al. (2023), who did a study on best practices and guidelines for mobile applications, they found that when apps were able to be customized, users were more likely to stay engaged and use the application more.

Design Principles and Strategies

Autism Accessible UI design encompasses a range of principles and strategies tailored to meet the diverse needs of autistic users. Visual clarity, consistency, and simplicity are emphasized to facilitate comprehension and reduce cognitive load (Parsons & Cobb, 2011). The use of clear, concise language, accompanied by visual supports such as icons or symbols, can enhance understanding and engagement (Scheetz et al., 2018). Additionally, customizable settings and flexible interaction options allow users to personalize their experience and accommodate individual preferences and sensitivities (Shire et al., 2017).

Visual Supports and Structure

Visual supports play a crucial role in Autism Accessible UI, providing additional cues and scaffolding for navigation and interaction. Visual schedules, grids, and hierarchical layouts help organize information and guide users through tasks (Van Laarhoven et al., 2017). Consistent visual design elements, including colour schemes, font styles, and spacing, promote predictability and reduce anxiety (Picard et al., 2016). Incorporating visual feedback and error cues enhances user feedback and promotes learning and skill development (Garrett et al., 2019).

Sensory Considerations

Sensory sensitivities are common among autistic individuals and influence their interaction preferences and comfort levels. Autism Accessible UI incorporates sensory-friendly design elements to minimize sensory overload and support user engagement. Options for adjusting audio, visual, and tactile stimuli allow users to regulate their sensory experiences and maintain optimal arousal levels (DePape & Weiss, 2012). Avoidance of abrupt transitions, flashing lights, and overwhelming animations mitigates sensory triggers and fosters a more inclusive user experience (Markoulakis et al., 2020).

Implications for Practice

The development and implementation of Autism Accessible UI present opportunities and challenges for designers, developers, educators, and practitioners. Collaborative partnerships between stakeholders, including autistic individuals, caregivers, and professionals, are essential to inform design decisions and ensure relevance and effectiveness (Knight et al., 2016). Continuous evaluation and refinement of Autism Accessible UI through user testing and feedback loops enable iterative improvements and ongoing optimization (Strickland et al., 2019). Furthermore, promoting awareness and advocacy for autism accessibility encourages greater adoption and integration of inclusive design practices across industries and sectors (Fletcher-Watson et al., 2020).

## Accessible Technology

According to Aguiar et al. (2020), technology for autistic people should be efficient and contain little to no faults. This is supported by Beals et al. (2015) who state that children with special needs need to enjoy using an app and find it interesting which could also be achieved by reducing faults in the final product. This will make development slower as all sections of the app will need to be repetitively tested and approved by stakeholders. However, all these studies were done only on children. Therefore, these restrictions may change as adults may be able to adapt more easily, which would improve progress.

### Importance of Accessible Technology

Accessible technology plays a critical role in fostering digital inclusion and empowering individuals with disabilities to fully engage in educational, professional, and social activities (Lazar et al., 2017). By removing barriers to access and participation, accessible technology enhances independence, productivity, and quality of life for people with disabilities (Goggin & Newell, 2007).

### Key Principles and Guidelines

Several key principles and guidelines inform the development of accessible technology, including the Web Content Accessibility Guidelines (WCAG) developed by the World Wide Web Consortium (W3C). WCAG provides recommendations for creating web content that is perceivable, operable, understandable, and robust for users with diverse abilities (W3C, 2018). Additionally, the principles of universal design advocate for designing products and environments that are usable by all individuals, regardless of age, ability, or status (Burgstahler, 2015).

### Challenges and Opportunities

Despite the growing awareness of accessibility issues, challenges persist in ensuring widespread adoption of accessible technology. These challenges include limited awareness and understanding of accessibility requirements among developers, inadequate resources for accessibility testing and remediation, and the rapid pace of technological innovation leading to accessibility gaps in emerging technologies (Vanderheiden & Treviranus, 2017).

However, accessible technology also presents significant opportunities for innovation and collaboration. Initiatives such as open-source software development, crowdsourced accessibility testing, and inclusive design competitions contribute to advancing accessibility in technology (Ellcessor, 2016). Furthermore, the adoption of inclusive design practices not only benefits individuals with disabilities but also improves usability and user experience for all users (Clark et al., 2018).

### Future Directions

Moving forward, continued efforts are needed to promote accessibility awareness, education, and advocacy among stakeholders across various sectors, including technology companies, government agencies, educational institutions, and non-profit organizations (Sloan et al., 2016). Collaboration between designers, developers, policymakers, and disability advocates is crucial for driving systemic change and ensuring that accessibility remains a fundamental consideration in technology development and implementation (Jaeger & Bowman, 2018).

In conclusion, accessible technology plays a vital role in promoting digital inclusion and equal participation for individuals with disabilities. By adhering to principles of accessibility and universal design, developers can create technology that is usable, equitable, and empowering for all users.

## Educational Technology

Several studies have identified that most apps dedicated towards autistic people or people with similar struggles focus on improving facial-processing abilities (Sung et al. 2015; Kientz et al. 2020). These types of educational activities can be extremely helpful for of all ages autistic people as this is a long-term difficulty that needs to be practised.

### Benefits of EdTech in Education

One of the key advantages of EdTech is its ability to personalize learning experiences and cater to diverse student needs. Adaptive learning technologies, for example, can dynamically adjust content and pace based on individual learning progress, fostering student engagement and mastery (Pane et al., 2017). Additionally, EdTech offers opportunities for active and experiential learning, enabling students to explore complex concepts through simulations, multimedia resources, and interactive activities (Khan, 2019). Furthermore, EdTech facilitates collaboration and communication, breaking down geographical barriers and enabling remote learning and virtual classrooms (Al Lily et al., 2020).

### Challenges and Considerations

Despite its potential benefits, the effective integration of EdTech into educational settings presents various challenges and considerations. Access and equity issues, including the digital divide and disparities in technology infrastructure and resources, can exacerbate inequalities in educational outcomes (Warschauer & Matuchniak, 2010). Moreover, concerns regarding data privacy, cybersecurity, and digital literacy underscore the importance of ethical and responsible use of technology in education (Selwyn, 2016). Additionally, the rapid pace of technological advancements necessitates ongoing professional development and support for educators to effectively utilize and integrate EdTech into their teaching practices (Ertmer et al., 2012).

### Future Directions and Implications

Looking ahead, the future of EdTech in education holds immense potential for innovation and transformation. Emerging technologies such as artificial intelligence, machine learning, and augmented reality promise to further revolutionize teaching and learning experiences (Bower et al., 2017). Additionally, the COVID-19 pandemic has accelerated the adoption of EdTech and highlighted the importance of flexible and resilient learning ecosystems (Hodges et al., 2020). However, realizing the full potential of EdTech requires a holistic approach that addresses technical, pedagogical, and socio-cultural factors, while prioritizing equity, accessibility, and inclusivity (UNESCO, 2020).

## Colour Psychology Concerning Neurodiverse Individuals

Colour psychology explores the impact of different colours on human behaviour, emotions, and cognition. When considering neurodiverse individuals, who may have conditions such as autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), or dyslexia, understanding how colours affect them is essential for creating environments conducive to their well-being and productivity.

Research suggests that neurodiverse individuals may have unique sensory experiences and sensitivities to stimuli, including colours. For example, individuals with ASD may exhibit heightened sensory perception, making them more sensitive to bright or intense colours (Grandin, 2010). Similarly, individuals with ADHD may find certain colours overstimulating, contributing to difficulties in concentration and focus (Fuermaier et al., 2018).

To accommodate the needs of neurodiverse individuals, it's crucial to consider colour choices in various environments, such as classrooms, workspaces, and healthcare facilities. Soft, muted colours like pastels or earth tones are often recommended, as they can create a calming and soothing atmosphere (Ashwood et al., 2017). Conversely, overly bright or contrasting colours may be overwhelming for some neurodiverse individuals and could potentially exacerbate sensory issues (Ashburner et al., 2008).

Moreover, the use of colour contrast can facilitate visual clarity for individuals with dyslexia or other reading difficulties. For instance, using dark text on a light background or vice versa can enhance readability and reduce visual stress (Wilkins, 2003). Additionally, incorporating colour-coded cues or visual aids can improve organization and comprehension for neurodiverse individuals in educational or workplace settings (Glen & Crilly, 2018).

In summary, colour psychology plays a significant role in creating inclusive environments for neurodiverse individuals. By carefully considering the impact of colours on sensory perception and cognitive function, designers and educators can enhance the well-being, comfort, and productivity of individuals with diverse neurological profiles.

## Legal, Social, Ethical and Professional Issues (LSEPIs)

### Data Protection Act

According to Stead, A., 2013. Information Rights in Practice: The non-legal professional’s guide:

1. Personal Data shall be processed fairly and lawfully and shall not be processed unless:
   1. at least one of the conditions at Schedule 2 is met,
   2. in the case of sensitive data, at least one of the conditions in Schedule 3 is also met.
2. Personal data shall be obtained for one or more specified and lawful purposes and shall not be further processed in a manner incompatible with that purpose or those purposes.
3. Personal data shall be adequate, relevant, and not excessive concerning the purpose or purposes for which they are provided.
4. Personal data shall be accurate and, where necessary, kept up to date.
5. Personal data processed for any purpose or purposes shall not be kept for longer than is necessary for that purpose or purposes.
6. Personal data shall be processed following the rights of the data subject.
7. Appropriate technical and organisational measures shall be taken against unauthorised or unlawful processing of personal data and accidental loss or destruction, or damage to, personal data.
8. Personal data shall not be transferred to a country or territory outside the European Economic Area unless that country or territory ensures an adequate level of protection for the rights and freedoms of data subjects concerning the processing of personal data. (DPA 1998, Schedule 1)

### Disability Discrimination Act

According to the Equality and Human Rights Commission, 2020:

1. Disability discrimination is when you are treated less well or put at a disadvantage for a reason that relates to your disability in one of the situations covered by the Equality Act.
2. The treatment could be a one-off action, the application of a rule or policy or the existence of physical or communication barriers which make accessing something difficult or impossible.
3. The discrimination does not have to be intentional to be unlawful.

NEW IDEAS

## Aims and Objectives

1. Research the needs and preferences of autistic people when it comes to communication.
2. Identify the specific features and functionalities required for the app from stakeholders.
3. Create the design and layout of the app.
4. Develop the app.
5. Test and debug the app to ensure it functions properly.
6. Monitor user feedback and make necessary updates to improve the app.

## Tasks and deliverables

1. Research
   1. Conduct interviews and surveys with autistic individuals and their caregivers to understand their communication needs and preferences.
   2. Review existing research and literature on communication strategies and interventions for autistic individuals.
   3. Analyse the data and information collected to identify common patterns and themes in the needs and preferences of autistic people.
   4. Document the research findings for reference.
2. Identify the specific features and functionalities required.
   1. Meet with stakeholders.
   2. Discuss requirements for the app.
   3. Identify specific features and functionalities needed.
3. Create the design and layout of the app.
   1. Research similar apps and user preferences.
   2. Sketch out initial ideas for the app's design and layout.
   3. Create wireframes or mock-ups to visualize the design.
   4. Gather feedback from stakeholders and make necessary revisions.
4. Development
   1. Decide on the platform or operating system for development.
      1. Evaluate the strengths and weaknesses of each platform or operating system.
      2. Discuss with team members or stakeholders about the preferred platform or operating system.
   2. Develop the app's functionality and features.
      1. Implement the app's features.
      2. Iterate and refine the app's functionality and features.
   3. Design and integrate user interface and user experience elements.
      1. Create visual elements such as buttons, menus, and icons.
      2. Consider the user's interaction and navigation within the app.
      3. Ensure consistency in the design and style throughout the app.
   4. Gather and analyse user feedback.
   5. Repeat the process with feedback in mind.
5. Testing.
   1. Test the app.
   2. Debug any issues.
   3. Test again until proper functionality.
6. User Feedback.
   1. Identify areas that need improvement.
   2. Make necessary updates to the app.

## Resources

### Interview with stakeholders.

* Learn technical requirements (Functions)
* Learn design requirements (Sounds and Colours)
* Find ideas of existing applications to research.

### Existing Applications

* Analyse reviews of apps to see what areas need focusing on.
* Make notes on features and design ideas.

### Autism websites and journals

* Research difficulties for autistic people to determine requirements and design features.

## Risks

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Risk** | **Solution** | **Impact** | **Likelihood** | **Overall Risk** |
| Stakeholders Unavailable | Regular meetings to ensure I have information in advance in case of change. | Medium | Low | Low |
| Not Accommodating all differences in autism | Interviewing autistic individuals to get a broad range of ideas | Medium | High | High |
| Deadline Changing | Have a plan in place so that if needed the development process can be expedited | High | Low | Medium |
| Bugs in Development | Regular testing opportunities to fix problems as they occur | Low | High | Medium |
| Change in Stakeholder Requirements | Regular demo opportunities for stakeholders to ensure quality | High | Medium | High |

Figure 1 - Project Timeline

A screenshot of a computer screen

Description automatically generated

## Agile Methodology

Agile methodology, particularly the SCRUM framework, represents an iterative and collaborative approach to software development. It emphasizes adaptability and customer feedback to deliver high-quality products efficiently. SCRUM, one of the most widely used Agile frameworks, operates on iterative cycles called sprints, focusing on continuous improvement and collaboration among cross-functional teams.

Within SCRUM, specific roles are defined to ensure effective team collaboration. The Product Owner represents stakeholders and manages the product backlog, prioritizing features based on business value. The SCRUM Master facilitates the process, removes obstacles, and ensures adherence to SCRUM principles. Meanwhile, the Development Team, comprising cross-functional members, is responsible for delivering increments of potentially shippable products at the end of each sprint.

Key artefacts within SCRUM include the Product Backlog, containing all desired product features, and the Sprint Backlog, a subset of items selected for implementation during a sprint. Each sprint concludes with an Increment, which is the sum of completed backlog items and should be potentially shippable and ready for review.

SCRUM events drive the iterative development process. Sprint Planning, held at the start of each sprint, involves selecting backlog items and creating a sprint backlog. Daily SCRUM meetings synchronize team members' work, while Sprint Reviews gather stakeholder feedback on completed increments. Sprint Retrospectives provide a forum for the team to reflect on their processes and make improvements.

SCRUM principles underpin its methodology. Iterative Development allows for frequent inspection and adaptation, fostering responsiveness to change. Collaboration promotes transparency and shared understanding among team members and stakeholders. Empirical Process Control relies on feedback and continuous improvement to optimize predictability. Finally, self-organization empowers teams to make decisions and adapt to evolving requirements.

As I am adopting an Agile methodology (SCRUM), the user feedback task shall be repeated regularly throughout development and testing to ensure all requirements by the stakeholders are met or to discuss changes/updates of features.

## Requirements (Before Interviews)

### Functional Requirements Table

| ID | Requirement Description |
| --- | --- |
| FR1 | Users must be able to register an account. |
| FR2 | Users must be able to log in to their accounts. |
| FR3 | Users must be able to create customizable communication profiles. |
| FR4 | Users must be able to communicate through images. |
| FR5 | Users might be able to share media files (images, videos, etc.). |
| FR6 | Users must have access to a library of pre-defined phrases/sentences. |
| FR7 | Users must be able to customize the app interface for their needs. |
| FR8 | Users could have access to a help/support feature. |
| FR9 | Users could have the ability to track their emotions/moods within the app. |

### Non-Functional Requirements Table

| ID | Requirement Description |
| --- | --- |
| NFR1 | The system must be available 24/7. |
| NFR2 | The system must be accessible on multiple platforms (iOS, Android, Web). |
| NFR3 | The system must have a user-friendly interface with clear navigation. |
| NFR4 | The system must prioritize simplicity and ease of use. |
| NFR5 | The system must be designed with input from autistic individuals and professionals. |
| NFR6 | The system must ensure data privacy and confidentiality. |
| NFR7 | The system must be responsive, with minimal latency in communication. |
| NFR8 | The system must comply with accessibility standards (WCAG) for users with disabilities. |
| NFR9 | The system must have regular updates and maintenance to address user feedback and improve functionality. |

## Interviewee Requirements

### Interviewee 1

| **ID** | **Requirement Description** |
| --- | --- |
| INT1\_1 | It needs lots of different options |
| INT1\_2 | It needs satisfying noises |
| INTI\_3 | Could have custom areas |

### Interviewee 2

| **ID** | **Requirement Description** |
| --- | --- |
| INT2\_1 | It needs to have clicked sounds for buttons |
| INT2\_2 | It needs vibrations if on a phone |
| INT2\_3 | It needs dark screen mode |
| INT2\_4 | It needs to be easy to find all the options |
| INT2\_5 | Could have settings for light levels and soundtracks |

### Interviewee 3

| **ID** | **Requirement Description** |
| --- | --- |
| INT3\_1 | It needs to have no required logins |
| INT3\_2 | It needs no ads |
| INT3\_3 | It needs reminders of rational thoughts (Database) |
| INT3\_4 | Could have a memory bank for positive reminders |

IMPLEMENTATION

## Design Choices

A screenshot of a computer

Description automatically generated

Figure 2 - First home page design.

The image displayed above, denoted as Figure 2, represents the preliminary UI design created for our application. The design was conceived with a vision of integrating pastel colours into the interface, which has been executed successfully in the navigation bar of the image. It should be noted that this design is still at a very basic stage and is meant to serve as a starting point for further ideation and exploration of various design components, including the colour palette and layout options.

A screenshot of a computer

Description automatically generated

Figure 3 - Second home page design.

The second iteration of the home page user interface design is depicted in Figure 3. As an essential part of the iterative process, I experimented with other design choices such as a side navigation bar, utilizing a distinct framework named Blazor.

Blazor is a contemporary web framework developed by Microsoft that enables developers to create interactive web applications using C# and .NET. It provides the flexibility of executing code either on the client side via WebAssembly or through server-side rendering. With its component-based approach, developers can create reusable UI components by using C# and Razor syntax, which simplifies development and promotes code reusability.

However, after due consideration, I chose not to use Blazor due to its complexity when compared to Razor Pages. The decision was influenced by the fact that it resulted in a slower development process, which was less than optimal given the short time frame available and the extensive design requirements.

A pink sign with black text

Description automatically generated

Figure 4 - Third home page design.

The third design iteration for the homepage of my application is presented in Figure 4. I have reached a final decision regarding the layout of the application, which now includes a top navigation bar and a bespoke logo in the pastel hues that I had previously chosen. I have generated a heading on the main home page that comprises the title of the website and a corresponding tagline. The heading serves as an essential component of the website's home page and provides visitors with an overview of the website's content and purpose. The title and tagline are crafted to be memorable and appealing while also accurately reflecting the website's central theme. This component is designed to enhance the overall user experience and ensure that visitors can quickly be introduced to the page.

A screenshot of a video game

Description automatically generated

Figure 5 - Fourth home page design.

The fourth design, as illustrated in Figure 5, features a limited number of emotional buttons that were deemed suitable for the final version. Consequently, this design was adopted for the development going forward, as it was deemed optimal for achieving the desired outcomes.

A screenshot of a video game

Description automatically generated

Figure 6 - Fifth home page design.

After experimenting to merge the second and third designs, I decided to abandon the concept of having a side navigation bar. The reason for this decision was that it was deemed too busy and complicated for my intended audience. Additionally, the colour palette of the navigation bar doesn't complement the overall design and appears incongruous.

A screenshot of a video game

Description automatically generated

Figure 7 - Final home page design.

Figure 7 shows the final design for an application. The colour palette has been updated to feature a friendly combination of blue and purple hues. This change intends to emphasize the relaxing atmosphere that the application aims to convey. I added a scroll wheel and title to the full array of emotion buttons to allow for more image types below if time permits.

|  |  |
| --- | --- |
| **ID** | **Implementation** |
| FR1, FR2,  FR3 | ASP.NET Razor Pages is a server-side web framework for building web applications, and it provides various features including account registration. It was used to quickly create account pages with appropriate customisation to match the overall app.    Figure 8 - Register and Login page before customisation.    Figure 9 - Register and Login page after customisation.  A palette comprising various shades of blues and purples was chosen to accentuate the tranquil ambience the app aimed to establish within the interface or design. This choice of colours was strategic, as it contributes to fostering a sense of relaxation and ease for the user, potentially enhancing their overall experience with the software. |
| FR4 | Leveraging Microsoft Copilot for image creation in my communication app streamlines the development process, maintains design consistency, and benefits from its adaptability and integration within my existing workflow. |
| FR7 | HTML and CSS help create a more customizable app for autistic individuals, adding colour and sounds that make the environment more comfortable for users. |
| FR8 | Razor Pages was used to create help/support pages to streamline the process using templates and page routing. |
| NFR1 | ASP.NET Core provides comprehensive tools for monitoring and diagnostics, including built-in logging, performance counters, and integration with third-party monitoring services. These tools enable developers to proactively identify and address issues that may impact the availability of the application, ensuring continuous uptime and minimizing downtime.  ASP.NET Core applications can also be containerized using technologies such as Docker, allowing for easy deployment and scaling across different environments. This containerization enables developers to deploy the application to cloud platforms such as Azure, AWS, or Google Cloud, providing flexibility in terms of hosting options and ensuring accessibility to users 24/7. |
| NFR2 | Using ASP.NET Razor Pages allows the app to be accessible on multiple platforms which supports all types of users. |
| NFR3, NFR4 | From my research, I found that calming colours like lighter shades of primary colours or pastels are better suited to ASD/neurodivergent users. Using HTML and CSS, I was able to implement this, alongside friendly comic-style fonts that would appeal more to my intended audience. I also used this to create clear, colourful buttons and a contrastingly coloured navigation bar that would allow clearer visibility. |
| NFR5 | I used interviews with neurodivergent individuals from the age ranges of 11-74. These were taken individually and in groups, however participants felt most comfortable. I also carried out further interviews throughout development to get additional input to ensure requirements were being met, as per my chosen agile methodology. |
| NFR6 | I used the ASP.NET framework to ensure data privacy and confidentiality as it encrypts data and saves it in a database only accessible by the developer. All data can be retrieved by the user at any time. |
| NFR7 | To ensure that the system is responsive with minimal latency in communication, I have used ASP.NET which has options for low latency to reduce background processes when there is high traffic. |
| NFR8 | To comply with accessibility standards (WCAG) for users with disabilities, all areas of the app contain clear buttons and engaging sounds. Additionally, there are bright colours and clearly labelled areas to improve visibility. |

## **Justifications**

### Asp.net framework

ASP.NET Framework is a powerful and widely used web development framework developed by Microsoft. It provides developers with a comprehensive platform for building dynamic web applications, web services, and websites. ASP.NET Framework is built on top of the .NET Framework and is specifically designed to simplify web development by offering a rich set of tools, libraries, and pre-built components.

One of the key features of ASP.NET Framework is its support for server-side scripting, which allows developers to create dynamic web pages by embedding server-side code directly into HTML markup. This server-side code can be written in languages such as C# or Visual Basic, providing developers with flexibility and familiarity in their development process. Additionally, the ASP.NET Framework offers a powerful event-driven programming model, allowing developers to respond to user actions and events easily.

Another important aspect of the ASP.NET Framework is its built-in security features, which help developers build secure web applications by providing mechanisms for authentication, authorization, and data encryption. ASP.NET Framework includes features such as membership and role management, form authentication, and encryption libraries, making it easier for developers to implement security best practices in their applications.

Furthermore, the ASP.NET Framework emphasizes scalability and performance, allowing developers to build high-performance web applications that can handle large volumes of traffic. It includes features such as caching, session state management, and asynchronous programming, enabling developers to optimize the performance of their applications and improve the user experience.

Pros:

* Integration with ASP.NET Core Identity: Razor Pages easily integrate with ASP.NET Core Identity, a membership system that adds login functionality to the application. This simplifies the process of implementing user registration, authentication, and authorisation.
* Security: ASP.NET Core Identity provides secure password hashing and storage mechanisms, preventing common security vulnerabilities like storing plaintext passwords. It also supports features such as account lockout to prevent brute-force attacks.
* Customization: Razor Pages allows for easy customization of the account registration process. This could be used for creating custom communication profiles.
* Validation: Razor Pages supports client-side and server-side validation, ensuring that user input is validated both on the client side (using JavaScript) and on the server side. This helps in preventing invalid or malicious data from being submitted during the registration process.
* Integration with other ASP.NET Core features: Razor Pages can easily integrate with other ASP.NET Core features such as dependency injection, middleware, and filters, allowing for a comprehensive and cohesive web application development experience.
* Unified Development Environment: ASP.NET Razor Pages allows developers to leverage a single development environment and codebase to build applications that can be deployed across multiple platforms, including web, mobile, and desktop.
* Cross-platform Compatibility: With ASP.NET Core, developers can target multiple platforms, including Windows, macOS, and Linux, for both server-side and client-side applications. This flexibility enables the creation of applications that can run seamlessly across different operating systems.
* Integration with Existing Technologies: ASP.NET Razor Pages seamlessly integrates with other Microsoft technologies, such as Azure services, Visual Studio IDE, and Entity Framework. This integration can simplify tasks such as deployment, debugging, and database management.
* Performance and Scalability: ASP.NET Core is designed for high performance and scalability, making it suitable for building multi-platform applications that can handle many users and concurrent requests.

Cons:

* Learning Curve: For developers who are new to ASP.NET Core or Razor Pages, there might be a learning curve in understanding how to implement account registration using this framework effectively. This could potentially slow down development initially.
* Complexity: While ASP.NET Core Identity simplifies many aspects of user authentication and registration, it can still introduce complexity, especially for more advanced scenarios or customizations. Developers may need to delve into the framework's documentation and APIs to understand and utilize its capabilities fully.
* Performance Overhead: ASP.NET Core Identity adds some performance overhead to the application due to its features like password hashing, token generation, and database operations for user management. While this overhead is generally negligible for most applications, it might be a consideration for high-performance or resource-constrained environments.
* Maintenance: As with any third-party library or framework, there is a level of maintenance involved. Developers need to ensure they stay up to date with framework updates, security patches, and best practices to maintain the security and reliability of the account registration system over time.
* Flexibility vs. Convention: While Razor Pages offer flexibility in customization, developers might find themselves constrained by the conventions and patterns enforced by ASP.NET Core Identity, which could lead to situations where implementing certain customizations or advanced features requires more effort or a workaround.

Overall, the ASP.NET Framework is a versatile and robust web development framework that provides developers with the tools and resources they need to build modern, secure, and scalable web applications. Whether building simple websites or complex enterprise applications, the ASP.NET Framework offers the flexibility, performance, and security required to meet the demands of today's web development landscape.

### Razor Pages

Razor Pages utilizes a simple and intuitive syntax that closely resembles HTML, making it easier for developers to create and maintain help/support pages. This simplicity enhances readability, allowing developers to focus more on the content rather than intricate coding structures. Each Razor Page corresponds directly to a URL, making it straightforward to organize and navigate help/support content. This direct mapping simplifies the management of URLs, improving SEO and ensuring users can easily access the information they need. In addition, Razor Pages supports a code-behind model, allowing developers to encapsulate page-specific logic within a separate class file, promoting clean and maintainable code, and facilitating easier debugging and future enhancements to the help/support pages.

Additionally, HTML provides a semantic structure, making it easier for screen readers and other assistive technologies to interpret the content. This ensures that the app is accessible to individuals with various cognitive and sensory needs, including those on the autism spectrum. The use of CSS allows for extensive customization of the app's visual appearance. Autistic individuals may have specific preferences or sensitivities to certain colours, fonts, or layouts. By utilizing CSS, developers can offer a range of customizable options, empowering users to tailor the app to their unique preferences and needs.

Autistic individuals may have sensory sensitivities that impact their interaction with digital interfaces. HTML and CSS provide the flexibility to design interfaces with considerations for sensory-friendly features such as clear layouts, minimal distractions, and adjustable contrast levels. Many autistic individuals also thrive on routines and familiarity. HTML and CSS are widely used technologies with established conventions and patterns and, by leveraging these technologies, developers can create interfaces that feel familiar and intuitive to users, potentially reducing cognitive load and increasing usability. Moreover, HTML and CSS facilitate the development of cross-platform applications that can run on various devices and operating systems. This ensures that the app is accessible to autistic individuals regardless of the device or platform they use, promoting inclusivity and reach.

### Microsoft Copilot

With Copilot's ability to quickly generate images based on natural language descriptions, I can accelerate the development process. Copilot assists in generating relevant images based on my verbal descriptions, saving time and effort. By leveraging Copilot's capabilities, it can ensure consistency in the visual elements of the app. The generated images align with the overall design language and style guidelines, maintaining coherence across different screens and features. Copilot adapts to various image requirements, from creating icons to illustrations, meeting diverse design needs without relying solely on pre-existing image libraries or external designers.

Integration: Copilot operates within integrated development environments (IDEs) like Visual Studio Code, seamlessly integrating into my existing workflow. This integration facilitates real-time collaboration and iteration, enabling me to refine and adjust the generated images as needed within the same development environment.

Learning and Improvement: As I interact with Copilot and provide feedback on its suggestions, the AI model learns and improves over time. This continuous learning process leads to more accurate and contextually relevant image generation, enhancing the quality of visuals in my communication app over successive iterations.

RESULTS AND DISCUSSION

In this section, I will delve into the rigorous testing process integral to the development of the software solution, adhering to the principles of an iterative Agile methodology. Testing is not merely a phase but a continuous, embedded practice throughout the software development lifecycle. An iterative approach emphasizes the nature of Agile development, where feedback loops drive refinement and evolution. Through a systematic exploration of functionalities, validation of requirements, and validation of system behaviours, the developer can ensure the reliability, functionality, and usability of the software. This section illuminates the comprehensive testing strategy, encompassing various testing techniques, tools, and frameworks employed to achieve quality assurance in alignment with Agile principles.

The Four levels of tests:  
1. Unit tests  
2. Integration tests  
3. System tests  
4. Acceptance tests

## Unit Testing

Unit testing is a cornerstone practice within software development methodologies, serving to ensure the reliability and correctness of individual components, or units, within a larger software system. Each unit, which can be a function, class, method, or module, is meticulously examined in isolation to validate its behaviour against specified requirements and design expectations.

The primary objective of unit testing is to identify defects early in the development process, thus minimizing the cost and effort required for rectification. By isolating each unit, developers can focus on testing its functionality independently of other components and external dependencies. This isolation is often achieved through the use of mocking or stubbing techniques to simulate the behaviour of dependencies such as databases, APIs, or external services.

Automation is a fundamental aspect of unit testing, enabling tests to be executed consistently and swiftly without manual intervention. Automated tests can be run frequently, providing rapid feedback to developers regarding the correctness of their code changes. This feedback loop is integral to maintaining the stability and quality of the codebase, as it allows for the timely detection and resolution of issues.

Within unit tests, assertions play a crucial role in verifying the expected behaviour of the units under examination. These assertions compare the actual output of the unit against predetermined outcomes, ensuring that the code behaves as intended. Additionally, achieving high code coverage—testing a significant portion of the codebase—is a common goal in unit testing, although it's essential to prioritize the quality and relevance of tests over sheer coverage metrics.

Ultimately, unit testing fosters a culture of quality assurance and continuous improvement within software development teams. By incorporating unit testing into their workflow, developers can increase the reliability, maintainability, and scalability of their software systems. Moreover, it facilitates the adoption of continuous integration and deployment practices, where code changes are validated automatically, leading to shorter development cycles and higher-quality software products.

## Integration Testing

Integration testing is a pivotal phase in software development, where individual units or components of a system are brought together and tested as a group to ensure seamless functionality. The software system is typically divided into smaller units or components, each responsible for specific tasks or functionalities. Integration testing involves combining these units or components according to the design specifications, which can be achieved in various ways such as integrating modules within a program or connecting different software services.

The primary focus of integration testing lies in testing the interactions between these units or components. This encompasses assessing how they communicate, exchange data, and collaborate to accomplish the desired functionality. By scrutinizing these interactions, integration testing helps identify issues that may arise when integrating different units or components, such as compatibility problems, interface mismatches, or unexpected behaviour due to interactions.

Integration testing encompasses various approaches, including top-down testing, bottom-up testing, big-bang testing, and incremental testing. Each approach has its advantages and is chosen based on the specific requirements and constraints of the project. Additionally, integration testing can be automated using testing frameworks and tools, streamlining the process, ensuring consistency, and facilitating continuous integration and deployment practices.

One of the key benefits of integration testing is its ability to ensure that individual units or components, which may work correctly in isolation, function properly when integrated into the larger system. By uncovering integration issues early in the development cycle, integration testing reduces the risk of costly defects in later stages. Ultimately, integration testing plays a vital role in verifying that different parts of a software system work together harmoniously, contributing to the overall reliability and quality of the software product.

## System Testing

System testing is a pivotal phase within the software development lifecycle, serving as a comprehensive examination of the entire software system. This rigorous testing occurs after integration testing and before acceptance testing, ensuring that all integrated components function seamlessly together and meet specified requirements. The primary objective of system testing is to validate the software system's adherence to both functional and non-functional requirements, encompassing its functionality, performance, reliability, security, and other critical characteristics.

During system testing, a carefully controlled test environment is employed, closely resembling the production environment. This environment ensures that the test results accurately reflect the system's behaviour under real-world conditions. Various types of tests are conducted, including functional testing to verify adherence to requirements, performance testing to assess responsiveness and scalability, security testing to identify vulnerabilities, usability testing to evaluate user-friendliness, compatibility testing across platforms, and regression testing to ensure existing functionality remains intact.

Test cases are meticulously developed based on system requirements and specifications, covering diverse scenarios to validate different aspects of the system's behaviour. Any defects or issues discovered during testing are meticulously reported, tracked, and managed using a defect-tracking system. This systematic approach ensures that identified issues are promptly addressed before the system is released to production.

Comprehensive documentation is an integral aspect of system testing, encompassing test plans, test cases, test results, and any issues identified during testing. This documentation serves as a vital reference for stakeholders and provides valuable insights for future maintenance and enhancements.

Overall, system testing plays a pivotal role in guaranteeing the quality, reliability, and effectiveness of the software system, mitigating risks, and ensuring a seamless user experience upon deployment.

## User Acceptance Testing

User Acceptance Testing (UAT) is a vital step in software development that ensures the quality and reliability of software systems. This process is designed to validate if a software product meets specified requirements and functions as intended from the end-user's perspective. UAT involves testing the software by representative end-users or stakeholders within a controlled environment. The primary goal of UAT is to assess if the software is suitable for deployment in real-world scenarios by scrutinizing its functionality, usability, and compliance with predefined criteria.

UAT requires active collaboration between developers, quality assurance professionals, and end-users to facilitate effective communication, feedback exchange, and issue resolution. The test cases should encompass various user interactions, input scenarios, and edge cases, which help uncover defects, inconsistencies, or deviations from expected outcomes. UAT's significance lies in its role as a quality assurance mechanism and in its contribution to a broader understanding of software engineering principles and practices.

In conclusion, User Acceptance Testing represents a pivotal phase in software development methodologies, embodying principles of user-centric design and quality assurance. Through systematic evaluation and collaboration, UAT endeavours to ensure that software systems meet user requirements, thereby facilitating their successful deployment and adoption in real-world contexts.

## Test Implementation

### First Test Iteration

|  |  |  |  |
| --- | --- | --- | --- |
| **What is being tested?** | **Expected outcome** | **Actual outcome** | **Test Type** |
| Home button | Return to the index page | Return to the index page | Unit Test |
| Sheep buttons | Goes to the relevant page and plays the associated audio | Goes to the relevant page and plays the associated audio | Unit Test |

### Second Test Iteration

|  |  |  |  |
| --- | --- | --- | --- |
| **What is being tested?** | **Expected outcome** | **Actual outcome** | **Test Type** |
| Register button | Move to the register page | Move to the register page | Unit Test |
| Password Strength Enforcement | Forces user to create a secure password with numbers and non-alphanumeric values | Forces user to create a secure password with numbers and non-alphanumeric values | Unit Test |
| Email confirmation button | Allows the user to confirm email without API implemented | Allows the user to confirm email without API implemented | Unit Test |
| Email enforcement | Forces the user to enter a valid email address | Forces the user to enter a valid email address | Unit Test |

### Third Test Iteration

|  |  |  |  |
| --- | --- | --- | --- |
| **What is being tested?** | **Expected outcome** | **Actual outcome** | **Test Type** |
| Crisis button | Move to the Crisis page and play audio | Move to the Crisis page and play audio | System Test |
| Crisis page audio controls | Allows the user to play/pause, adjust playback speed and mute | Allows the user to play/pause, adjust playback speed and mute | System Test |
| Download personal data | It gives the user their data from the relevant database | It gives the user their data from the relevant database | Integration Test |
| Delete account | Remove the selected user's account from the database | Remove the selected user's account from the database | Integration Test |
| Change password | Changes the user’s password value in the database | Changes the user’s password value in the database | Integration Test |
| Change email | Sends confirmation email to new email and updates the email value in the database | API for sending emails is not implemented as it requires payment, however, the scaffolding for the feature is implemented | Integration Test |
| 2 Factor Authentication | Creates recovery codes and forces when using login | Creates recovery codes and forces when using login | System Test |

### Fourth Test Iteration (UAT)

|  |  |
| --- | --- |
| **User Feedback** | **How I addressed this (If needed)** |
| "The help button is not functioning properly." | It is imperative to implement the absent features of the help button to guarantee its proper functionality. To ensure that the system operates smoothly and effectively, by addressing and resolving any issues with the help button. Therefore, it is essential to take prompt action to rectify the problem and ensure that the help button works as intended. |
| “Love the colours, very mellow and unobtrusive” | This feedback aligns with the overarching goal of creating user-friendly and visually appealing interfaces conducive to relaxation and engagement.  The characterization of the colours as "mellow and unobtrusive" suggests that the chosen colour scheme successfully achieved its intended effect of promoting a soothing and non-intrusive visual experience for users. This sentiment is consistent with the principles of colour psychology, which posit that certain hues and combinations can evoke specific emotional responses and contribute to overall user satisfaction.  Moreover, the positive feedback regarding the colour palettes corroborates the findings of previous research emphasizing the importance of colour in shaping user perceptions and behaviours within digital environments. By consciously selecting colours known for their calming and harmonious qualities, the interfaces were able to foster a sense of tranquillity and enhance the overall user experience. |
| “I like the sheep and all the different choices” | The use of anthropomorphic characters, such as sheep, not only adds visual interest but also fosters a sense of familiarity and playfulness for users. Additionally, the availability of diverse choices within the interface allows users to personalize their experience and select options that resonate with their preferences.  The feedback regarding the sheep characters and the range of choices reinforces the importance of incorporating inclusive design elements that cater to diverse user preferences. By providing options that appeal to different tastes and sensibilities, designers can create more engaging and enjoyable experiences for users across various demographics, including those with neurodivergent profiles.  Furthermore, this feedback underscores the significance of leveraging emotionally resonant elements, such as cute characters, to enhance user engagement and interaction. The positive response to the sheep characters indicates their potential to elicit positive emotions and foster a sense of connection with the interface, ultimately contributing to a more immersive and satisfying user experience. |

## Automated Testing

Katalon Studio is a powerful test automation tool designed to streamline the process of software testing and quality assurance. Developed by Katalon LLC, it offers a comprehensive suite of features to assist testers in creating, executing, and managing automated tests efficiently (Katalon LLC, n.d.).

One of the key features of Katalon Studio is its user-friendly interface, which allows testers with varying levels of technical expertise to create automated tests without extensive programming knowledge. The tool provides a range of built-in keywords and components for test case creation, making it accessible to both beginners and experienced testers alike (Katalon LLC, n.d.).

Katalon Studio supports multiple testing frameworks, including Selenium and Appium, enabling testers to automate web, mobile, and API testing from a single platform. This versatility makes it a preferred choice for organizations seeking to automate testing across different platforms and technologies (Katalon LLC, n.d.).

Furthermore, Katalon Studio offers robust reporting and analytics capabilities, allowing testers to generate comprehensive test reports and track key metrics to assess the quality and stability of their applications. This visibility into test results helps teams identify and prioritize areas for improvement, facilitating faster and more informed decision-making (Katalon LLC, n.d.).

In addition to its core features, Katalon Studio provides seamless integration with popular continuous integration (CI) tools such as Jenkins and Bamboo, enabling teams to incorporate automated testing into their existing development workflows effortlessly (Katalon LLC, n.d.).

A screen shot of a computer program

Description automatically generated

Figure 10 - Automated test for emotion buttons.

CONCLUSIONS AND FUTURE WORK

In conclusion, this project explored communication apps for autistic individuals by conducting a comprehensive literature review and utilising Agile development to gain insights into the needs and preferences of neurodivergent individuals in a technological environment.

One of the main findings of this project is the importance of calming colour palettes. This suggests a significant implication for various contexts, particularly in environments where promoting relaxation, focus, or well-being is essential. Calming colour palettes, characterized by soft, muted tones and harmonious combinations, have been shown to influence individuals' moods, emotions, and overall perception of space.

In practical terms, this finding underscores the potential for leveraging colour psychology in neurodivergent application design, educational settings, and other environments where creating a serene atmosphere is paramount. By strategically incorporating calming colour palettes into these spaces, designers and developers can foster a sense of tranquillity, reduce stress levels, and enhance the overall quality of user experience.

Furthermore, the analysis revealed users engaged significantly more with the cute characters. Underscoring the importance of creating digital content and interfaces that are not only visually appealing but also resonate with specific user demographics. Inclusive design principles emphasize the importance of considering the full spectrum of human diversity, including cognitive differences such as autism. By acknowledging and accommodating the preferences and sensitivities of autistic users, designers can create more accessible and engaging experiences for all individuals.

Moreover, the preference for cute characters among autistic users underscores the potential for leveraging emotionally resonant elements to enhance user engagement and interaction. Cute characters, with their charming and endearing qualities, can evoke positive emotions and foster a sense of connection, particularly among individuals who may experience challenges in traditional social interactions.

This finding also highlights the broader significance of user-centred design approaches, which prioritize understanding the unique perspectives and needs of target users throughout the design process. By conducting user research, gathering feedback, and incorporating insights from diverse user groups, designers can create more inclusive and impactful products and experiences.

Furthermore, the importance of incorporating cute characters in digital content extends beyond specific user demographics to encompass broader usability and engagement goals. Whether targeting autistic users or the general population, the appeal of cute characters can enhance the overall user experience, increase user satisfaction, and potentially even drive user retention and loyalty.

Moreover, this research has contributed to the existing body of knowledge in software engineering by showing the importance of acceptance in neurodivergent applications. By addressing different ages and differences in needs, this study has shed light on understanding how accommodating diverse user demographics, including individuals with neurodevelopmental differences, can profoundly impact the usability and effectiveness of software applications.

By specifically addressing the varying needs and preferences of users across different ages and neurodivergent profiles, this study has illuminated the complexities inherent in designing inclusive software solutions. It highlights the necessity of adopting a user-centred approach that prioritizes acceptance and embraces diversity as a fundamental principle in software engineering practices.

The findings also underscore the importance of moving beyond a one-size-fits-all approach and instead tailoring applications to accommodate the unique characteristics and requirements of neurodivergent users. By recognizing and accommodating differences in sensory processing, cognitive styles, and interaction preferences, developers can create more accessible and user-friendly software experiences.

Additionally, this research has practical implications for software developers, designers, and stakeholders involved in the creation of digital products. It emphasizes the need for incorporating features and design elements that promote acceptance and inclusivity from the initial stages of development. By integrating accessibility considerations into the design process, developers can proactively address the diverse needs of users and mitigate potential barriers to engagement and usability.

However, it is important to acknowledge the limitations of this research, such as time constraints meaning a lack of researched required features fully implemented. Future studies could overcome these limitations by the ability to fully implement all the researched features necessary for comprehensive neurodivergent-friendly applications. While extensive research was conducted to understand the diverse needs and preferences of neurodivergent users, practical constraints may have restricted the scope of features implemented within the study.

Future studies could overcome these limitations by building upon the foundational research conducted in this study and further refining the implementation of identified features. While the current research provides valuable insights into the importance of acceptance and inclusivity in software engineering, there remains a wealth of potential features and design considerations that could be explored and integrated into future iterations of neurodivergent-friendly applications.

Future research endeavours must prioritize the translation of research findings into practical implementations that directly address the identified needs of neurodivergent users. This may involve allocating additional resources and time to ensure that a more comprehensive range of features is incorporated into the design and development process.

By clearly communicating the extent of the research conducted and the rationale behind the implementation choices made within the study, researchers can provide transparency regarding the limitations of the current research while also laying the groundwork for future advancements in the field of neurodivergent-friendly design.

Overall, the findings of this dissertation have significant practical implications for technology developers, designers, and companies operating in the digital space. By uncovering the importance of calming colour palettes and the engagement of autistic users with cute characters, this research offers valuable insights that can directly influence the creation and implementation of digital products and interfaces.

For technology developers and designers, the emphasis on calming colour palettes underscores the critical role of colour psychology in user experience design. Understanding how colours can impact users' emotions, attention, and overall perception of digital interfaces is essential for creating visually appealing and engaging experiences. By incorporating calming colour palettes into their designs, developers can create interfaces that promote relaxation, reduce stress, and enhance user satisfaction.

Similarly, recognizing the preference of autistic users for cute characters highlights the importance of incorporating inclusive design elements into digital products. By integrating cute characters into user interfaces, applications, and websites, developers can create more engaging and accessible experiences for users across the neurodiversity spectrum. This approach not only fosters inclusivity but also enhances user engagement and interaction, leading to higher levels of user satisfaction and retention.

Businesses operating in the technology sector can leverage these insights to gain a competitive edge and drive positive outcomes. By implementing design strategies informed by colour psychology and inclusive design principles, companies can differentiate their products in the market, attract a broader user base, and foster stronger connections with their customers. Additionally, by prioritizing user experience and accessibility, companies can demonstrate their commitment to diversity and inclusion, building brand trust and loyalty among consumers.

Moreover, policymakers and regulatory bodies can use these findings to inform guidelines and standards aimed at promoting accessibility and inclusivity in digital technologies. By advocating for the adoption of inclusive design practices and ensuring compliance with accessibility standards, policymakers can help create a more inclusive digital ecosystem that benefits users of all abilities.

In summary, the practical implications of this dissertation extend to technology development, design, and policy, highlighting the importance of incorporating principles of colour psychology and inclusive design into digital products and interfaces. By embracing these insights, stakeholders in the technology sector can create more engaging, accessible, and inclusive experiences for users, ultimately driving positive outcomes for both businesses and society.

In conclusion, this dissertation has provided valuable insights into inclusive applications, laying the groundwork for future investigations in this area. As we continue to build upon this research, I hope that the findings presented here will contribute to positive advancements and innovations in inclusive software engineering.

##### Appendix

## Interview Permission

A document with writing on it

Description automatically generated

A close-up of a form

Description automatically generated

A close-up of a form

Description automatically generated

##### References

Aguiar, Y.P.C. et al., 2022. AutismGuide: a usability guidelines to design software solutions for users with autism spectrum disorder. Behaviour & information technology, 41(6), pp.1132–1150. 10.1080/0144929X.2020.1856927.

Al Lily, A. E., Ismail, A. F., Abunasser, F. M., & Alqahtani, R. H. (2020). Distance education as a response to pandemics: Coronavirus and Arab culture. Technology in Society, 63, 101317.

Althaus, M. et al. (1996) ‘Information processing and aspects of visual attention in children with the DSM-III-R diagnosis “Pervasive developmental disorder not otherwise specified” (PDDNOS): I. Focused and divided attention’, Child Neuropsychology, 2(1), pp. 17–29. doi:10.1080/09297049608401347.

Anderson, D. K., Lord, C., Risi, S., DiLavore, P. S., Shulman, C., Thurm, A., ... & Pickles, A. (2007). Patterns of growth in verbal abilities among children with autism spectrum disorder. Journal of consulting and clinical psychology, 75(4), 594–604.

Ashburner, J., Ziviani, J., & Rodger, S. (2008). Sensory processing and classroom emotional, behavioral, and educational outcomes in children with autism spectrum disorder. The American Journal of Occupational Therapy, 62(5), 564–573.

Ashwood, K. L., Gillan, N., Horder, J., Hayward, H., Woodhouse, E., McEwen, F. S., ... & Murphy, D. G. (2017). Predicting the diagnosis of autism in adults using the Autism-Spectrum Quotient (AQ) questionnaire. Psychological Medicine, 47(14), 2427–2436.

Ausderau, K. K., Furlong, M., Sideris, J., Bulluck, J., Little, L. M., Watson, L. R., ... & Baranek, G. T. (2014). Sensory subtypes and associated outcomes in children with autism spectrum disorders. Autism Research, 7(6), 711-722.

Beals, Katharine, and Katharine Beals. Speech and Language Technology for Language Disorders. De Gruyter, 2016.

Behrmann, M., Thomas, C., & Humphreys, K. (2006). Seeing it differently: visual processing in autism. Trends in Cognitive Sciences, 10(6), 258-264.

Ben-Sasson, A., Hen, L., Fluss, R., Cermak, S. A., Engel-Yeger, B., & Gal, E. (2009). A meta-analysis of sensory modulation symptoms in individuals with autism spectrum disorders. Journal of Autism and Developmental Disorders, 39(1), 1-11.

Boyd, B. A., Baranek, G. T., Sideris, J., Poe, M. D., Watson, L. R., Patten, E., & Miller, H. (2010). Sensory features and repetitive behaviors in children with autism and developmental delays. Autism Research, 3(2), 78-87.

Bower, M., Lee, M. J., & Dalgarno, B. (2017). Collaborative learning across physical and virtual worlds: Factors supporting and constraining learners in a blended reality environment. British Journal of Educational Technology, 48(2), 407-430.

Burgstahler, S. (2015). Universal design in higher education: Promising practices. Journal of Postsecondary Education and Disability, 28(2), 135-149.

CDC, 2023. Signs and Symptoms of Autism Spectrum Disorders [online]. Centers for Disease Control and Prevention. Available at: https://www.cdc.gov/ncbddd/autism/signs.html [Accessed 26 February 2024].

Clark, C., Meiselwitz, G., & Leong, T. W. (2018). Universal design and technology trends: Achieving universal access in the digital era. International Journal of Human-Computer Interaction, 34(11), 1017-1022.

Data Protection Act 2018 (no date) Legislation.gov.uk. King’s Printer of Acts of Parliament. Available at: https://www.legislation.gov.uk/ukpga/2018/12/contents/enacted (Accessed: 27 October 2023).

Davis, M. et al., 2010. Guidelines for researchers and practitioners designing software and software trials for children with autism. Journal of assistive technologies, 4(1), pp.38–48. 10.5042/jat.2010.0043.

DePape, A. M., & Weiss, J. A. (2012). Sensory over-responsivity and anxiety in children with autism spectrum disorders. Autism, 16(2), 243-252.

Doybls (2020) ‎Leeloo AAC - Autism Speech App, App Store. Available at: https://apps.apple.com/us/app/leeloo-aac-autism-speech-app/id1508952198 (Accessed: 18 October 2023).

Ellcessor, E. (2016). Accessible technology and participatory culture: The case of American Council of the Blind v. Hulu. Television & New Media, 17(6), 555-573.

Equality and human rights commission (2020). Disability Discrimination | Equality and Human Rights Commission. [online] Equalityhumanrights.com. Available at: <https://www.equalityhumanrights.com/en/advice-and-guidance/disability-discrimination>.

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. Computers & Education, 59(2), 423-435.

Fletcher-Watson, S., Adams, J., Brook, K., Charman, T., Crane, L., Cusack, J., ... & Pellicano, E. (2020). Making the future together: Shaping autism research through meaningful participation. Autism, 24(1), 27-41.

Fuermaier, A. B., Tucha, L., Koerts, J., & Tucha, O. (2018). Measurement of wandering in children with ADHD: A preliminary study. Journal of Attention Disorders, 22(2), 155–163.

Garrett, J. M., Hadadgar, A., & Knight, V. F. (2019). Autism and user-centered design of technology for people: A systematic literature review. International Journal of Human-Computer Interaction, 35(1), 1-18.

Glen, T., & Crilly, N. (2018). Design for inclusivity: A practical guide to accessible, innovative and user-centred design. Routledge.

Goggin, G., & Newell, C. (2007). Digital disability: The social construction of disability in new media. Rowman & Littlefield.

Grandin, T. (2010). Developing talents: Careers for individuals with Asperger syndrome and high-functioning autism. Future Horizons.

Green, S. A., Ben-Sasson, A., Soto, T. W., & Carter, A. S. (2012). Anxiety and sensory over-responsivity in toddlers with autism spectrum disorders: Bidirectional effects across time. Journal of Autism and Developmental Disorders, 42(6), 1112–1119.

Happé, F., & Frith, U. (2006). The weak coherence account: detail-focused cognitive style in autism spectrum disorders. Journal of autism and developmental disorders, 36(1), 5-25.

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. Educause Review, 27.

Horton, S., & Quesenbery, W. (2014). A Web for everyone: Designing accessible user experiences. Rosenfeld Media.

Howlin, P., Goode, S., Hutton, J., & Rutter, M. (2004). Adult outcome for children with autism. Journal of Child Psychology and Psychiatry, 45(2), 212–229.

Jaeger, P. T., & Bowman, C. A. (2018). Advancing accessibility through policy and advocacy. In K. Shilton & A. Sayago (Eds.), The Cambridge Handbook of Computing and Information Ethics (pp. 303-326). Cambridge University Press.

Kaiser, M. D., Shiffrar, M., & Pelphrey, K. A. (2010). Socially tuned: brain responses differentiating human and animal motion. Social Neuroscience, 5(3), 277-291.

Kasari, C., Kaiser, A., Goods, K., Nietfeld, J., Mathy, P., Landa, R., ... & Almirall, D. (2014). Communication interventions for minimally verbal children with autism: A sequential multiple assignment randomized trial. Journal of the American Academy of Child & Adolescent Psychiatry, 53(6), 635–646.

Katalon LLC. (n.d.). Katalon Studio: The Best Test Automation Solution. Retrieved from <https://www.katalon.com/>

Khan, B. H. (2019). The global e-learning framework. Routledge.

Kientz, J.A. et al., 2020. Mobile Applications [online]. Synthesis lectures on assistive, rehabilitative, and health-preserving technologies, pp.55–67. Available at: https://link.springer.com/chapter/10.1007/978-3-031-01604-2\_4 [Accessed 21 February 2024].

Knight, V. F., McKissick, B. R., & Saunders, A. (2016). Use of design thinking to develop autism-appropriate technology. In Design thinking research (pp. 123-142). Springer, Cham.

Lazar, J., Goldstein, D. F., & Taylor, A. (2017). Ensuring digital accessibility through process and policy. Morgan Kaufmann.

Leekam, S. R., Nieto, C., Libby, S. J., Wing, L., & Gould, J. (2007). Describing the sensory abnormalities of children and adults with autism. Journal of Autism and Developmental Disorders, 37(5), 894-910.

Liu, X. et al., 2023. A Survey on Autism Care, Diagnosis, and Intervention Based on Mobile Apps: Focusing on Usability and Software Design [online]. Sensors, 23(14), pp.6260–6260. Available at: https://www.mdpi.com/1424-8220/23/14/6260 [Accessed 21 February 2024].

Markoulakis, R., Lal, S., & Wright, C. (2020). "Epilepsy and Autism (2020)" in Epilepsy & Behavior. Epilepsy & Behavior, 106, 107053.

McMahon, K. et al., 2019. A path from childhood sensory processing disorder to anxiety disorders: The mediating role of emotion dysregulation and adult sensory processing disorder symptoms. Frontiers in integrative neuroscience, 13, pp.22–22. 10.3389/fnint.2019.00022.

Means, B., Bakia, M., & Murphy, R. (2013). Learning online: What research tells us about whether, when and how. Routledge.

Microsoft Copilot: Your everyday AI companion [online]. Microsoft Copilot: Your everyday AI companion. Available at: https://copilot.microsoft.com/ [Accessed 23 February 2024].

Pane, J. F., Griffin, B. A., McCaffrey, D. F., & Karam, R. (2017). Effectiveness of cognitive tutor algebra I at scale. Educational Evaluation and Policy Analysis, 39(1), 33-61.

Parsons, S., & Cobb, S. (2011). State-of-the-art of virtual reality technologies for children on the autism spectrum. European Journal of Special Needs Education, 26(3), 355-366.

Picard, L., Marin, L., & Renaud, C. (2016). Autism spectrum disorder: An augmented literature review. Autism, 20(5), 513-531.

Plaisted, K., O'Riordan, M., & Baron-Cohen, S. (1998). Enhanced visual search for a conjunctive target in autism: A research note. Journal of Child Psychology and Psychiatry, 39(5), 777-783.

Robertson, A. E., & Baron-Cohen, S. (2017). Sensory perception in autism. Nature Reviews Neuroscience, 18(11), 671-684.

Robertson, A. E., & Simmons, D. R. (2013). The relationship between sensory sensitivity and autistic traits in the general population. Journal of Autism and Developmental Disorders, 43(4), 775-784.

Scheetz, N., Johnston, T., Plumb, A. M., Lutzker, A., & McComas, J. J. (2018). Exploring communication supports for students with autism spectrum disorder: A systematic review. Exceptionality, 26(3), 147-170.

Selwyn, N. (2016). Education and technology: Key issues and debates. Bloomsbury Publishing.

Shire, S. Y., Gulsrud, A., & Kasari, C. (2017). Increasing responsive parent–child interactions and joint engagement: Comparing the influence of parent-mediated intervention and parent psychoeducation. Journal of Autism and Developmental Disorders, 47(3), 632-645.

Sloan, D., Kelly, B., Heath, A., & Petrie, H. (2016). Considering accessibility earlier in the web development lifecycle: Introducing the ADL methodology. In Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility (pp. 261-262).

Strickland, D. C., Marcus, L. M., Mesibov, G., & Hogan, K. (2019). Brief report: Facilitating the recruitment of people with autism spectrum disorders into research studies. Journal of Autism and Developmental Disorders, 49(4), 1748-1754.

UNESCO. (2020). UNESCO recommendation concerning open educational resources (OER). Retrieved from <https://en.unesco.org/sites/default/files/oer_recommendation_1928_1.pdf>

Van Laarhoven, T., Kraal, A., Nijhof, A. D., & van Woerkom, M. (2017). Developing the autism & developmental disabilities observational coding system for use in field settings. Research in Developmental Disabilities, 60, 176-184.

Vanderheiden, G. C., & Treviranus, J. (2017). ICT and the future of accessibility. In S. Vos & W. Hamza (Eds.), Computers Helping People with Special Needs (pp. 3-12). Springer.

Warschauer, M., & Matuchniak, T. (2010). New technology and digital worlds: Analyzing evidence of equity in access, use, and outcomes. Review of Research in Education, 34(1), 179-225.

Wilkins, A. J. (2003). Reading through colour: How coloured filters can reduce reading difficulty, eye strain, and headaches. John Wiley & Sons.

World Wide Web Consortium (W3C). (2018). Web Content Accessibility Guidelines (WCAG) Overview. Retrieved from <https://www.w3.org/WAI/standards-guidelines/wcag/>