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Designing a Chat-Bot for Non-Verbal Children on the Autism Spectrum

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Abstract. There is a significant amount of anecdotal evidence of the benefits of individuals on the autism spectrum interacting with technology via natural language. Many of these individuals are non-verbal but still able to communicate via augmentative and alternative communication (AAC) aids. This paper presents the design of a AAC software program (app) with embedded artificial conversational agent, called *Alex*. Alex runs on a Android device and is able to engage with the user on a variety of topics using symbols and images. Alex may be programmed via speech and occupational therapists and other key stakeholders via speech and hence does not require any specialised computer skills. The importance of customisation, interoperability, personalisation and motor skill considerations is herein discussed.

Keywords. autism, augmentative and alternative communication, natural language processing, artificial intelligence

Introduction

Human computer interaction is increasingly expanding into natural human language. Conversational agents (also called dialogue systems) are systems that interpret what the user has conveyed and reply with an appropriate response. The first widely known dialogue agent is perhaps Siri which was developed by Apple Inc. and released globally in 2011 [1]. This was followed by Alexa in 2014 developed by Amazon [2].

These devices primarily act as virtual assistants in that they respond to interrogative and imperative statements. There is another category of conversation agents commonly referred to as chat-bots that are attracting attention due their ability to handle unstructured dialogue. Chat-bots and virtual assistants for health applications in the past have included behaviour change for obesity and diabetes [3], disease self-management [4], and health education for adolescents on topics related to sex, drugs and alcohol [5], and cognitive behaviour therapy for mental health issues [6].

There is a a growing body of anecdotal evidence from parental blogs [7] and books [8] on the benefits of these technologies for individuals on the autism spectrum. This perhaps isn't too surprising as it is well established that individuals on the spectrum gravitate towards technology for education and entertainment [9,10,11] . This has been attributed to the audio-visual appeal, limited sensory information, and the user having the locus of control [12].

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A significant portion of individuals on the autism spectrum are at some point categorised non-verbal. An individual may later become verbal, many however, remain non-verbal for life. This does not mean they cannot communicate, but rather, require other means. With the ubiquitous use of mobile technologies such as smartphones and tablets, software-based assistive technologies have become increasingly available. In the case of augmentative and alternative communication (AAC) systems, the introduction of tablets was revolutionary due to their relqtively low cost, portability, and resulting increase in social acceptance of AAC [13,14].

This paper presents the development of an AAC app with an embedded chat-bot herein referred to as *Alex*. Alex is designed for use by people on the autism spectrum. Programming Alex does not need any specialist skills and is designed for speech therapists, parents and other key stakeholders to contribute what they deem relevant. The user is able to practice spontaneous conversation with Alex in a safe, non-judgemental environment. The long term aim of this research is examining the validity of intervention based on artificial intelligence that augments conventional therapy.

1. Application Design and Discussion

As aided AAC is the the most effective form of AAC for children on the autism spectrum [15], a system based on visual symbols was implemented, as opposed to integration with unaided AAC such as sign language [16]. High-tech aided AAC often incorporates speech-generating devices [14], so speech will be integrated as well.

Autism is characterised as a spectrum condition due to the heterogeneity of the needs of individuals with the condition. As such, the application needs to be highly customisable to suit these needs. In relation to a mobile application, variation in motor skills, language and sensory sensitivities are the primary considerations.

1.1. Layout

Aided AAC systems represent symbols through a grid display, or a visual scene display (VSD). Grid display is a common layout for AAC systems, where symbols are placed in specific positions within a grid. As each symbol is isolated, it supports the recall of the individual contents of each cell [17]. A grid display also allows a large vocabulary, as the grid can be layered to provide more symbol access [14].

VSD embed symbols within a naturalistic scene, providing context to its use. As the symbols displayed are inherently linked to the context of the scene, it supports a smaller, context-specific vocabulary which can be generalised [15,17] .

A grid display was selected as it provides a broader vocabulary appropriate for engaging in unstructured conversation. The default layout is a 4 by 10 grid, and can be modified based on the grid content. Although research supports benefits in using animated symbols for AAC use by children [18], these studies do not address the need to reduce the visual-cognitive load of the AAC display [13], nor include participants on the autism spectrum. As such, the initial version of the application was designed to use static symbols.

Grid layouts are usually arranged by either activity, taxonomy, theme or word type, with the effectiveness of the layout varying depending on the individual [17]. The theme layout was selected as it is generally better understood by younger children and better connects with visuals than the word types themselves.

Within the page, symbols are arranged in the Fitzgerald Key format, ordered left to right in order of appearance in the sentence [19]. Symbols are colour coded as per the Modified Fitzgerald Key, extending on the colours established in the Fitzgerald Key. The primary grid is arranged with core vocabulary based on English language word frequency data [20], as well as by examining pre-existing boards publicly shared in the Coughdrop AAC app [21]. Secondary grids are linked to the original grid with symbols, expanding themes and allowing access to word variations. Only two layers are used, as to maintain the interest of the user [22]. For example, by pressing the symbol 'who', the second layer is opened, which contains symbols related to people such as family members, and extensions such as 'whose'. The original symbol is in the same position on the second layer, allowing for double taps to access the intended symbol. This consistent format allows for motor planning [22].

1.2. Chat-Bot

Unstructured dialogue systems such as chat-bots allow the user to practice speaking, without having to work towards specific goals in the dialogue [23]. A range of modules designed to teach skills that have been suggested as valuable to the autistic population (bullying, social skills, job interview, executive functioning). Potentially Alex could be used at home to further skills built upon in therapy as research indicates that children interact with conversational agents using the same language they use with family [24].

Figure 1 shows the main grid display of the AAC app. Also shown is a interaction between the user and Alex using symbols and text. In this instance the user has selected the symbol for 'Hello' (shown in green on the top row in Figure 1) and the Alex has responded with a meaningful response (shown in the green, second row in Figure 1). In order to produce a meaningful responses Alex relies on case-based reasoning and textual pattern matching algorithms in particular the use of a standardised computer language referred to as Artificial Intelligence Mark-up Language (AIML) [25].

AIML is based on the Common Extensible Mark-up Language (XML) which utilises tags to identify commands and specific input stimuli and responses. AIML is based on basic units of dialogue formed from user input patterns and respective chat-bot response. Creation of AIML content requires no advanced computer programming skill and this has likely contributed to the significant amount of content already released by bot-masters. As of 2018, a large collection of AIML sets have been released under the GNU public license making them freely available.

1.3. Interoperability and Personalisation

Open Board Format is used to store data related to the layout of the symbols [30]. Open Board Format files (.obf and .obz) have been introduced as a future standard for digital AAC boards to ensure interoperability of communication boards between devices. .obf files are based on the common JavaScript Object Notation (JSON) format, and contain information regarding the symbols themselves and their corresponding images. .obz are zips of .obf bundled with their image files, as well as a manifest file which describes the connections between the boards. By importing and exporting boards in this layout, users

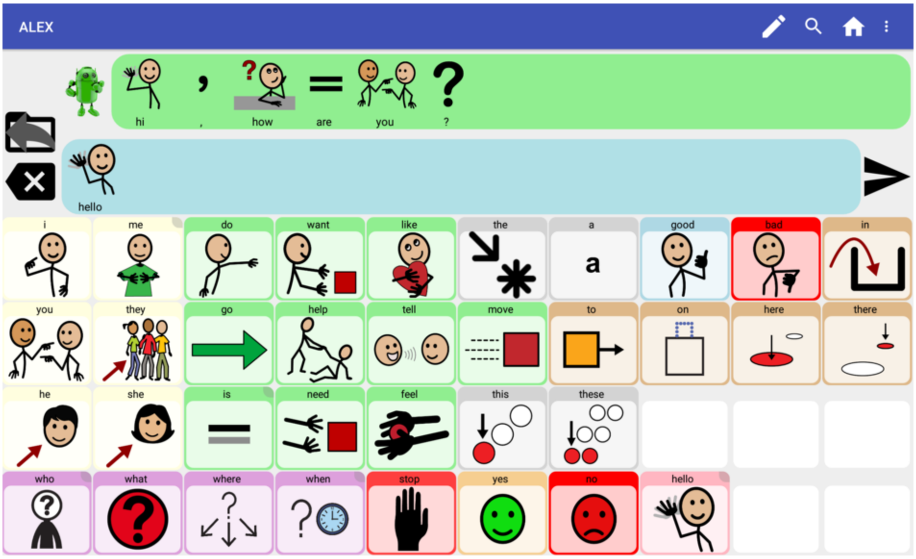

Figure 1. Example of conversation using AAC. The blue box holds the user input, and the green box shows Alex's response. Icons licensed under Creative Commons [26,27,28], as well as SymbolStix [29].

are able to transfer their AAC boards between different applications which support this format, as well as access open source boards.

A high degree of customisability is built into the app such that the layout and vocabulary of the grid can be personalised. Custom boards can be imported or created, and the dimensions of the grid layout altered to match this content. Symbols can be customised, rearranged and added to include user-specific vocabulary. A comprehensive search feature is included so the user can search the inbuilt symbol dictionary of over 15000 symbols for symbols to add to the board or be used in general conversation. As shown in Figure 2 new symbols can be created using an image from the device, allowing for default images of items to be replaced by photos of items from the user's life. Customisation options can be password-locked to prevent unexpected changes.

1.4. Motor Skills Considerations

Challenges with motor skills can make it difficult for the user to select buttons to communicate. A benefit of mobile technology is that it can be used to improve accessibility [31]. The grid size is customisable such that the buttons can be enlarged so they are easier to press. Communication with the chat-bot can still occur with these larger sizes. An example is if the board was set up with two buttons, 'Yes' and 'No'. The user can still engage with the bot through yes/no questions about a range of topics. A large vocabulary can still be accessed with fewer buttons by having buttons linking to other boards. It is to be noted that too many layers of boards can hinder communication due to the time taken to find appropriate meaning, and the potential of loss of interest [22].

The application is compatible with alternative access features for Android, including eye gaze and head mouse. The inclusion of alternative access features in AAC is emphasised to ensure user accessibility [13] and is particularly relevant as 8% of children with cerebral palsy are on the autism spectrum [32].

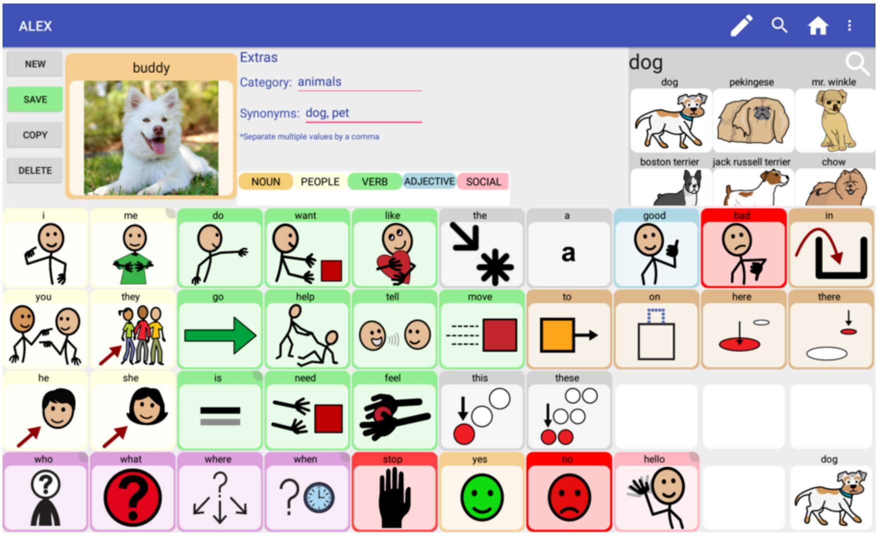

Figure 2. Edit toolbar to customise symbols.

2. Conclusion

This paper has summarised the design of an AAC interface for interacting with a autism-specific chat-bot. By providing AAC integration, there is the potential to utilise such a chat-bot in therapy, remote monitoring, education and entertainment for a individual who may be non-verbal. Future work includes engaging with focus groups to improve design and functionality as a response to this feedback. Symbol prediction features are also to be incorporated as it's expected this can significantly speed up AAC-based conversations.

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