Sentiment Analysis for Emotional Navigation in Written Communication: What Support do Autistic People Need?

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Abstract: A subfield of artificial intelligence is that of natural language processing and sentiment analysis. The interest in sentiment analysis has increased with the development of the internet and web 2.0. With sentiment analysis it is possible to analyse the sentiment or emotions of written communication through dictionary-based sentiment analysis or machine learning algorithms. However, sentiment analysis also holds the potential of supporting people with disadvantages in interpreting the nuances in written communication. One such group is autistic people. The aim of the study is to examine autistic peoples' perceptions of important design factors and functionality for an application with sentiment analysis to support emotional navigation in written communication. This study has been conducted with the first steps of design science to outline the requirements of a potential application that can support autistic people to navigate the emotions in written communication with sentiment analysis. The problem to be addressed was identified through related research and one of authors' own experience of navigating written communications with autism. The requirements for the application were the main focus for this study and has been the primarily concern for data collection. Data have been collected through semi-structured interviews with autistic people and analysed with thematic analysis. Results of the study provide several important recommendations for the design of applications with sentiment analysis to support autistic people navigate the emotions in written communication. The study further provides an understanding of autistic peoples' needs when navigating written communication. These findings can be used by researchers and developers to design support-applications with autistic peoples' needs in the centre. An interesting next step of research would be to develop a prototype with the findings of this study addressed in the application's functionality and design, which could then be evaluated on a larger scale.

Keywords: sentiment analysis, affordances, design science, autism, support application

1. Introduction

The interest in sentiment analysis has increased with advancement of internet and Web 2.0. A reason for this could be a desire to take advantage of the massive quantity of data generated on the internet every single day. A big part of this data comes from social media. Nowadays, social media is used by businesses just as much as by people. Businesses use social media to advertise, communicate and understand their customers. (Drus & Khalid, 2019)

Sentiment analysis is an approach that makes use of Natural Language Processing (NPL) to analyse and extract sentiment and emotion from written text (Solakidis, Vavliakis & Mitkas, 2014). This is often conducted through text classification, data mining, machine learning, or other AI techniques (Xu et al., 2019). Sentiment analysis could further be used to assist autistic people in interpreting sentiment and emotion in written communication.

Autism, also known as autism spectrum disorder or ASD, is an umbrella term for disabilities characterised by an impairment in skills needed for socialisation and communication, as well as a need for rigid routine. In addition to this, autistic people could also present intellectual, sensory, and motor deficiencies. However, it is important to note that autism is heterogenous and each individual present their own strengths and weaknesses (Madsen et al., 2009). According to Crompton et al. (2019), autistic people often communicate effectively between themselves, as neurotypical people (people without neurological or developmental disabilities) often do between themselves.

Sentiment analysis could be used to support autistic people interpret sentiment and emotions in written communication by neurotypical people, as this is where most miscommunication arises (Crompton et al., 2020). This could be done through a mobile application for sentiment analysis, as most written communication these days tend to be through mobile devices. The focus of this study is on autistic peoples' thoughts and opinions and will therefore incorporate the idea of participatory design with participation of autistic people.

The aim of the study is to examine autistic peoples' perceptions of important design factors and functionality for an application with sentiment analysis to support emotional navigation in written communication. The study has been guided by the following research questions:

- RQ1) What needs do autistic people have on functionality in applications that analyse sentiment and emotions in written communication?
- RQ2) What needs do autistic people have on design in applications that analyse sentiment and emotions in written communication?

2. Background

In this study, the concept 'autistic person' is used, rather than 'person with autism'. There is no clear consensus on which term is correct but a study by Kenny et al. (2015) shows that the concept 'autistic' is largely accepted among autistic people while used less frequently by professionals, that more often uses 'person with autism'. The choice to use 'autistic' is based on the acceptance among autistic people and on one of the authors own experiences of being an autistic person. In the subheadings below, a brief overview of related research and the theoretical framework used for the study are presented. Subheading *2.1 Related research* presents related research with a focus on sentiment analysis and participatory design. Subheading *2.2 Affordances* presents the theory of Affordances which has been used as the theoretical framework for the study.

2.1 Related research

Sorensen et al. (2022) have created an interactive sculpture that visualizes and sonifies emotions expressed around the world through big data analysis of Twitter. These emotions were coded into different colours, patterns, and sounds (Sorensen et al., 2022). The study by Sorensen et al. (2022) uses *Hourglass Of Emotions* (Susanto et al., 2020) a psychologically motivated model consisting of 24 emotions, with 24 corresponding colours to categorise emotions and visualise them in the sculpture. The 24 emotions consist of eight basic emotions, in three different intensities. In a similar way, Tian, He and Wang (2022) collected and analysed tweets, but for a different reason. The purpose of their study was to analyse tweets for emotional content to be able to discover and handle PR-crises appropriately (Tian, He & Wang, 2022). Tweets were analysed on emotional occurrence and intensity (Tian, He & Wang, 2022). The study by Tian, He and Wang (2022) used *Plutchik Wheel Of Emotions* (Plutchik, 1982), which consists of eight basic emotions (anger, anticipation, disgust, fear, joy, sadness, surprise, and trust) and arranges these emotions in four paradoxical pairs (joy-sadness, anger-fear, trust-disgust, and anticipation-surprise).

Participatory design has been developing since the 1970s and was originally used to involve workers in the development and design of factories, as they were the ones who spent time there (Drain, Shekar & Grigg, 2021). Participatory design in the IT-field has the same aim, to involve potential users in the development of artefacts. An example of participatory design with autistic people is Cha et al. (2021), where autistic adolescents were involved in the possible adaptation and use of existing voice-based conversational agents for empowering and strengthening different skills in autistic individuals. Cha et al. (2021) states that an overwhelming part of studies tend to focus on guardians' and healthcare staffs' opinions, rather than autistic individuals' thoughts and opinions. The study by Cha et al. (2021), show that voice-based conversational agents were able to engage autistic individuals, help them handle and understand their emotions, practice self-care, and further develop their communication skills. These findings might not have been possible if the study would have focused on guardians and healthcare staffs instead.

2.2 Affordances

The concept 'affordances' refer to the possibility of interaction between individuals and their surroundings. The term was first coined by the psychologist James Gibson in the 1960s (Withagen et al., 2012). The idea of affordances mean that we live in a world of possibilities for interactions, but that do not mean that we necessarily will act on all those possibilities. Two ideas from Gibson's affordances are especially interesting: First, the concept of affordances suggests that the environment itself is meaningful; Second, the world is filled with opportunities, rather than reasons (Withagen et al. 2012). The concept of affordances was introduced in human-computer-interactions (HCI) by Donald Norman (Lanamäki, Thapa & Stendal, 2016). Norman (1999) highlights three important aspects of how people know how to interact with novel artefacts: perceived affordances, constraints, and an appropriate conceptual model.

According to Norman (1999), affordances play very different roles in the design of physical products and in system development. In system development, perceived affordances tend to be more relevant since these can be manipulated by the system designer (Norman, 1999). Perceived affordances are what the user perceive to

be possible actions to take in the system (Norman, 1999). While most of the physical and built-in affordances of a computer, such as the looking, touching, and pointing of the computer screen and mouse, are of little interest in the design of applications (Norman, 1999).

Constraints are restrictions to what a user can and cannot do in a system. Norman (1999) identifies three types of constraints: physical constraints, logical constraints, and cultural constraints. Norman (1999) further assert that constraints are powerful tools for design since they can guide the user to meaningful actions. Physical constraints are things the user cannot do, for example: move the cursor outside of the screen (Norman, 1999). Logical constraints are often used to guide users' behaviour (Norman, 1999). Logical constraints could be used to get a user through a series of actions and move to the next part of a procedure. Cultural constraints could also be understood as conventions, shared by a certain group of people. A cultural constraint encourages or discourages specific actions, such as to only click on the mouse when the correct cursor form appears (Norman, 1999).

3. Method

The study was carried out with a qualitative approach inspired by Design Science. Design science could be defined as a process to identify and address real-world problems through design, implementation, and development of artefacts (Johannesson & Perjons, 2014). Johannesson and Perjons (2014) suggests five steps for Design Science: 1) Explicate the problem, 2) Define the requirements, 3) Design and develop the artefact, 4) Demonstrate the artefact, and 5) Evaluate the artefact.

This study addresses the first two steps of the Design Science-model, with a focus on examining autistic peoples' perceptions of important design factors and functionality for an application with sentiment analysis. The first step of the study, explicate the problem, has been identified through previous research (presented in the Introduction and Background) and through one of the authors own experiences as an autistic individual. The second step, define the requirements, has been addressed through semi-structured interviews with autistic people. The process for data collection and analysis are presented in subheadings below.

3.1 Data collection

Data have been collected through five semi-structured interviews with five different respondents. Taking into consideration that the study has aimed to understand autistic peoples' needs, all respondents were autistic. Semi-structured interviews were chosen as the method for data collection because of the flexibility that it offers. Semi-structured interviews made it possible to change order of questions in the interviews and to ask follow-up questions to the respondents' answers (Bryman, 2016). This flexibility provided respondents the opportunity to talk freely on the subject, while still allowing for questions to clarify when needed. The interviews focused on mainly two aspects of a potential application, sentiment analysis functionality and design, with affordances and constraints as supporting questions.

All interviews were conducted through the digital meeting tool Zoom. This allowed for the interviews to be recorded and easily accessible for analysis. Each interview started with respondent presentation and after that the main interview was conducted. The order of the questions asked vary between the interviews but in general the interviews followed a similar pattern, and the same questions were covered. All interviews ended with a final question where respondents were asked to summarise what they considered to be most important and if they though that something had been missing in the interview. Respondents in the interviews were between 20 and 60 years old and both male (1), female (3), and non-binary (1).

3.2 Data analysis

Data analysis has been conducted with thematic analysis to interpret and identify the themes or "patterns of meaning" in the collected data (Clarke, Braun, & Hayfield, 2015). The process of conducting a thematic analysis can be described in six phases: 1) Familiarisation, 2) Coding, 3) Theme development, 4) Reviewing themes, 5) Defining themes, and 6) Produce report (Terry et al., 2017). In this study, a deductive coding approach has been used with Affordances as the theoretical framework. With this approach, the second and third phase was shifted in the process of analysis. A description of the analysis process through the six phases are provided below.

In the first phase, familiarisation with the collected data was reached through transcribing the recorded interviews and reading (and re-reading) the transcripts while taking notes. In the second phase, theme development was conducted based on the categories used for questions in the interviews, related research, and the theoretical framework of Affordances. The pre-defined categories used for analysis consisted of *Sentiment analysis functionality* and *Application design*, with the sub-categories of *Affordances* and *Constraints* under each. In the third phase, coding of collected data were conducted through reviewing the transcription of each interview and colour-coding extracts of the material, corresponding to colours to the pre-defined categories. After that, extracts were collected in two separate text-documents, on for each theme.

In the fourth phase, all codes and themes were revised for consistency and controlled for relevance for the aim and research questions of the study. In the fifth phase, themes were defined through highlighting the common denominator of the included extracts and codes. In the last phase, the report of the analysis was produced and presented in the Results and analysis-section. Themes related to *Sentiment analysis functionality* are presented in subheading 4.1, and themes related to *Application design* are presented in subheading 4.2.

4. Results and analysis

In this section, results of the study's analysis of the collected data are presented. The first subheading (*4.1 Sentiment analysis*) presents results on sentiment analysis functionality for a potential application. The second subheading (*4.2 Design*) presents results on design for a potential application. Quotes presented in the subheading have been translated and rewritten for readability. However, the underlying meaning have not been changed.

4.1 Sentiment analysis

The respondents highlight needs for support in understanding feelings and emotions in written communication, prevent overanalysing content in written communication, and minimise anxiety related to interpreting feelings and emotions in written communication (Quote 1). Participants highlight that analysis of feelings and emotions should be conducted on larger amounts of text, at least whole paragraphs, since the analysis otherwise would risk being "too chopped up", overwhelming, and potentially incorrect. Sentence-focused analysis would further leave to the user to do the whole text-analysis, which could be problematic for autistic people. An alternative that is highlighted by the participants is that the user should be able to choose which parts of the text that will be analysed.

> *"To better understand and relate to written text that I find difficult to interpret. I would normally overanalyse, even though I don't really understand."*
>
> ***Quote 1**. Participant about application support to prevent overanalysing written communication.*

The respondents highlight concerns for the analysis working less correct with shorter messages, messages with little or no context, and messages with heavy use of slang and sociolect (Quote 2). The respondents further highlight how feedback from the analysis should be presented. The most common suggestion was to provide feedback in written form. For example, "this text is neutral" or "this text is happy". Another suggestion was to provide feedback from the analysis in the form of emojis that correspond the with emotions in the text. Yet another suggestion was to provide feedback from the analysis in graded-scale format, where emotions identified in the text are graded based on how common or how strong they are expressed.

> *"It feels difficult that an application should interpret what is said between the lines in only one sentence. It feels like that would easier create misunderstandings."*
>
> ***Quote 2**. Participant about potential problems with using sentiment analysis on shorter texts.*

4.2 Design

The respondents highlight needs for the design to be structured, easy to work with, have a clear visual style, and be adaptable. It is highlighted that a simple layout is preferred, where the visual input and stimuli is kept to a bare minimum (Quote 3). It is further considered important that the application allow for adaptation and customisation. Some suggestions for the adaptations and customisations that the user should be allowed to do in the application are to decide what is shown on the screen and control potential sound effects in the application.

> *"If you're on the internet, there are these webpages where too much irrelevant things have been stuffed along the sides. I don't only think about advertisements, but also that you place a pretty flower there or something else. Don't mess it up."*
>
> ***Quote 3**. Participant about not making the visual design messy.*

The respondents highlight concerns for a messy, unstructured, and overwhelming design (Quote 4). It is also highlighted that lack of adaptation and customisation, especially regarding text presentation, could be problematic since some of the respondents have dyslexia and visual impairments. Opinions regarding colours in the visual design is varied, but a common notion is that the colours used should provide easy readability. It is further common among the respondents that sound effects are not desirable. Respondents explain that they often have their phones set on silent mode and that they consider sound effects to be an undesired interruption.

> *"Also, it should not be too much. It should remain quite structured so that you know what you are reading about. It shouldn't be too messy and everything all at once. You should be able to click and choose."*
>
> ***Quote 4**. Participant about application not being messy and unstructured.*

5. Discussion

The study by Cha et al. (2021) focuses on autistic peoples' opinions and thoughts on voice-based conversational agents and if this technology could support in everyday life. The study show that voice-based conversational agents can support users in understanding and managing emotions, practice self-care, and further develop communication skills (Cha et al., 2021). Similarly, this study indicates that autistic people could be supported by an application with sentiment analysis to understand emotions in written communication. This would likely also affect autistic peoples' navigation of written communication in general, for example by lessen feelings of anxiety for interpreting emotions incorrectly.

However, as noted by the study's results, the possibilities for support by an application with sentiment analysis heavily relies on the application's functionality and design. It is important to find the appropriate level of sentiment analysis, provide clear and concise feedback, and that the application and analysis can be customised by the user. These needs expressed by the autistic people in the study might sound small and insignificant to neurotypical persons (individuals without neurological or developmental disabilities), but to an autistic person, adaptability could make the difference if an application can be used at all. Different autistic people have different sensory needs and there is no 'one size fits all'-solution. Including autistic people in development of support-applications with sentiment analysis is crucial.

Sorensen et al. (2022) uses the model *Hourglass Of Emotions* (Susanto et al., 2020), with 24 emotions to map emotions extracted from tweets. Tian, He & Wang (2022) uses *Plutchik Wheel Of Emotions* (Plutchik, 1982), with eight basic emotions, for a similar purpose. This study does not apply any models or frameworks for identifying or understanding specific emotions, which could be considered a limitation of the study. The rationale for not including this in this stage of research was that focus should instead be on autistic peoples' needs regarding functionality and design of the application. However, in future research with a prototype for the application it would be interesting to apply different models for emotions to investigate which model participants prefer for navigation emotions in written communication.

The study has been conducted with a limited number of participants which could be considered yet another limitation of the study. Therefore, results presented in this study should not be generalised but seen as an indication. This study is an early exploration of autistic peoples' perceptions and needs of an application with sentiment analysis to support emotional navigation in written communication and has focused on the initial steps of the Design science process. The initial results of the study indicate a need for an application with sentiment analysis to support autistic people in emotional navigation of written communication. Future research should focus on developing a prototype and testing this with a larger number of participants. This could be conducted with focus groups to capture nuances in the evaluation and would preferable also include user data to identify navigation and potential bugs in the application.

6. Conclusion

The aim of the study was to examine autistic peoples' perceptions of important design factors and functionality for an application with sentiment analysis to support emotional navigation in written communication. This has included examining autistic peoples' needs regarding both functionality and design in a potential application. The study shows that there is a need for applications with sentiment analysis to support autistic people in emotional navigation of written communication. The study further highlights important design factors and functionality that should guide future development of applications with sentiment analysis directed for autistic people.

The results of the study provide a groundwork for making reality of an application with sentiment analysis that can support autistic people in emotional navigation of written communication. An application that supports the understanding of emotions in written communication would be an important aid in many autistic individuals' lives since it could lessen the anxiety for socialising. An application with sentiment analysis, directed for autistic people, could also be an appreciated support for neurotypical people (people without neurological or developmental disabilities), since written communication can be vague to anyone.

However, a potential risk of developing these types of applications is that autistic individuals could feel that their own abilities and judgements are not enough or cannot be trusted. It is therefore of utmost importance that development emphasises applications as assistance when emotional content is unclear and not as a replacement for autistic peoples' abilities and judgments. Future development should also include autistic people in the design process through participatory design, to ensure that it is autistic peoples' needs that are realised in the applications and not neurotypical peoples' assumptions.

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