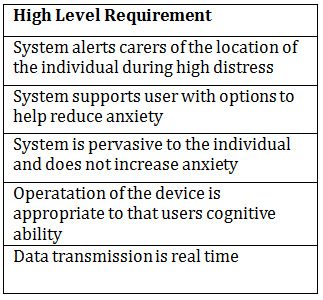
Autism Spectrum Disorders (ASD) are development disabilities that cause substantial impairments in social interaction and communication and the presence of unusual behaviours and interests. Many people with ASDs also have unusual ways of learning, paying attention, and reacting to different sensations. The thinking and learning abilities of people with ASDs can vary—from gifted to severely challenged. (Gillberg, 1990). In its worst form autism can lead to self-harm or an individual putting themself into a dangerous situation. A unique challenge of developing devices to assist with autism is that the introduction of a new object can itself cause distress (Kientz *et al.,* 2007).

Autism is a pervasive developmental disorder, in that an individual may show no external signs of being affected (Lord, 1989). Pervasive computing, hidden technology, could offer great assistance to those with ASD whilst causing only minimum interference to their daily lives. Mark Weiser, considered the father of ubiquitous computing, wrote “The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it … Such a disappearance is a fundamental consequence not of technology, but of human psychology” (Weiser, 1991).

Autism sufferers can become extremely agitated at seemingly trivial events. There are multiple reasons why escalations occur. People with autism often have sensory processing deficits, including problems in modulating sensory input (Ornitz *et al.,* 1985) and many autistic people feel fearful and anxious about sound (Steigler *et al.,* 2010). This article examines how ubiquitous computing could be used to monitor for loud noises which leads to a rise in the individuals’ anxiety. Technology would then attempt to calm the individual, and in extreme circumstances raise an alert if there are signs of danger. Figure 1 shows a brief summary of high level requirements for a device created to assist this vulnerable population.

Developing a system for a vulnerable user will require an extensive research period, focused on obtaining qualitative and quantitative data from carers, family members, medical staff, and where possible the ASD sufferers themselves. The data collection process is discussed in the identifying requirements section.

Figure - High Level Requirements

Ethics

In its charter the British Computer Society (BSC Code of Conduct, 2011) has four principles of ethics for its members to adhere to -

1. The Public Interest
2. Duty to Relevant Authority
3. Duty to the Profession
4. Professional Competence and Integrity

Every stage of the project must be tested against the BSC principles, and with consultation from all stakeholders in the study. Working with the vulnerable population opens the researcher up to allegations of an abuse of trust. As well as the moral implications, any perceived unethical behaviour would bring negative publicity and damage the project.

Acknowledgement of limitations

Assisting ASD requires a qualified specialist with a high degree of time, patience and personalisation to assist the individuals unique condition. Each individual has their own range of motor skills, and for some, using a device that requires interaction may be impossible. Whilst there are some common traits in the disorder, the best course of assistance will need to be unique to the individual. The author acknowledges that any device will not be applicable to all sufferers of ASD.

Loud noises and panic attacks

Sounds that can cause problems are high-pitched motor noises, such as vacuum cleaners, air condition fans, and electric drills (Bemporad, 1979). Adults on the autism spectrum may be prone to anxiety or distress, which in extreme situations could lead to panic attacks. Panic attacks are a terrifying experience where the body reacts as if it is in immense danger. Adrenalin released into the blood stream causes the heart to beat faster (Synapse, 2012). Outside of the home unexpected loud noises are unavoidable and the consequences for someone with ASD could be a failure to respond to a fire alarm, or losing control and putting themselves at risk, for example by running into a road.

Pervasive computing will be used to monitor the environment, activating whenever a sudden increase in noise occurs. The users heart rate will be monitored to detect signs of panic, and decide appropriate actions for the user based on their unique criteria.

The device

The device has to be discreet , so it will be manufactured in the form of a watch that measures both the decibel level and the users’ heart rate. If the heart rate increase significantly the watch will display a message asking if the user is okay, and requesting them to press a button to acknowledge the message. The user will be alerted that the watch requires a response by a vibration on the wrist. A large screen display must adhere to Nielsen’s heuristics, be particularly aesthetic and minimalist in design. For instance a detection of a loud noise, followed by an increase in heart pressure, would display a message ‘ARE YOU OKAY?’ with only two buttons to select, ‘yes’ or ‘no’, allowing a user who is regaining control to deactivate the warning (Nielsen *et al.,* 1994).

For decision support the user would have another device (e.g. mobile phone) which would play a pre-recorded video when the watch transmits distress. The video would contain instructions from a trusted friend (or the user themselves) giving a clear, calming message. This personalisation allows for unique assistance to that user and negates some of the problems with developing a standardised solution for such a heterogeneous cohort of users.

If the user does not respond to the watch, or the heart rate has reached a level recognised as extreme, a message and location will be transmitted to the users’ carer requesting they contact the individual. If the user has a history of violence or self-injury, then an alert would be transmitted to the emergency services.

Potential device issues

There are several scenarios which would need to be considered during the design stage. Examples include what happens when individuals are in areas without 3G , false readings being sent to the emergency services, the distress caused to all parties if a device malfunctions and the secure protection of the data stored. This article does not propose solutions for these issues, but acknowledges that it is essential for them to be resolved before product launch.

Project planning

To create this device I will use the waterfall model. This model best suits a solo project because the rigid structure provides a very clear framework for each section.A more flexible model, such as an iterative process, would be better for a larger team who had the resources to constantly revise each section of the work. Working alone means that if constant revisions are required then the project is more likely to overrun (Amlani, 2012).

Identifying Requirements - Behavioural Patterns – Estimate time taken- three months

Due to the vast differentiation in types of autism, a quantitative research approach would be initiated to ascertain common methods for reducing anxiety during distress. Carers will be approached as they have experience with multiple individuals with ASD and will be aware of successful techniques. Data from questionnaires can be of low quality (Dix *et al,. 2004)*  so at this stage the carers will also be asked if they consent to interviews, and also if they know anyone with ASD who they feel would be capable and comfortable to be interviewed on their experiences.

ASD sufferers may find talking to a new person about their condition and experiences distressing and create a mistrust which would hinder future co-operation. For this type of research a person of trust (family member or carer) would need to arrange and supervise the interviews. Full anonymity would be offered to all partaking in the study.

Secondary research sourced from either governmental, medical, or education authorities would provide both qualitative and quantitative data. The information gathered would be used to develop techniques to be used in the videos.

Identifying Requirements – Heart rate patterns –Estimate time taken - three months (at the same time as behavioural patterns research)

Volunteer participants, with and without ASD, would be asked to wear a decibel monitor and have their heart rate recorded over a three month period to build a real time database to analyse and identify patterns. It is acknowledged that field studies like this have disadvantages - a lack of context, willingness of users to co-operate, periods where no relevant data is collected and the associated cost (Dix et al,. 2004). However in this scenario a laboratory study would not be appropriate. Whilst volunteers without ASD may consent to allowing the researcher to create an unexpected loud noise, clearly it is highly unethical to do this to someone with autism.

The implications of monitoring any individual causes ethical questions. The most vulnerable ASD sufferers, hence those most likely to provide valuable data, may not have the cognitive ability to comprehend that they are being monitored. Approval from trustees and authoritative boards would be required. The Mental Capacity Act 2005 states that in the UK ‘ *To undertake research with those who lack capacity, the MCA requires a researcher to obtain approval from an ‘appropriate body’. This Body must be satisfied that the research project meets certain requirements set out in the MCA and that arrangements are in place to consult a family member, friend or unpaid carer about ... taking part in research of this type*.’ (Social Care Institute for Excellence, 2009).

Design Stage – Estimate time taken - two months

A tender for the manufacturer to build the hardware would be released, whilst the necessary software was mapped into UML diagrams with relevant use case tests produced to ensure satisfaction of all high level requirements. Correctly mapping the heart rate patterns into working algorithms would be a lengthy task, requiring co-operation from medical experts.

Implementation Stage – Estimate time taken - two to three months

This would involve regular communication with the manufacturer, carers, medical experts and ASD individuals to ensure that the product is being developed in a way which will be suitable for operation by the user. An essential requirement is that the devices can be operated during distress. At the end of this stage a prototype would be created.

Verification Stage – Estimate time taken - three to six months

An evolutionary approach will be applied to the prototype, with incremental changes made based on user and carer feedback. It is critical that we identify any false readings from the device, either raising an alarm when there is no distress, or more critically not raising an alarm when there is distress. When the operation has been deemed satisfactory over a couple of months and demonstrated to have been effective in assisting ASD, the product will be released.

If the requirements and design have not been undertaken to a high enough quality a lengthy redesign may be necessary at this point, highlighting the importance of each waterfall stage.

Maintenance Stage – Client determined

As this is a medical product it can be assumed that the client would expect the developer to continue maintaining and refining the product for a lengthy period, possibly with no initial fixed end date. Due to the nature of biometrics it could be several years before all scenarios have been tested and bugs identified.

Evaluation

Much of the evaluation would be done during the verification stage. Evaluation has three main goals: to assess the extent and accessibility of the system’s functionality, to assess users’ experience of the interaction, and to identify any specific problems with the system. These may be aspects of the design which, when used in their intended context, cause unexpected results, or confusion amongst users. (Dix, A *et al.,* 2004).

To evaluate that the device has been successful users and carers would need to conclude that –

* The device has truly blended into the background, and does not cause annoyance, confusion or stress
* The device is activated each time a loud noise occurs, and the video set to be played
* The device can be operated and understood during mild distress
* Users have found that the wearing of it increases confidence and reduces anxiety and would therefore recommend it
* When a user has entered an extreme state, carers or authorities have been correctly alerted
* As the user is a vulnerable person in a distressing situation, it is critical that the device does not transmit false alerts

Because of their frequent interactions with ASD patients carers will be asked (and trained) to undertake observational studies to collect data and feedback from users which would then be analysed to study the effectiveness of the product. One on one interviews with these carers would be arranged to add context and personal thoughts to the data. This is the best method to obtain qualitative and quantitative data.

With the same careful approach taken during the research phase, ASD individuals would be interviewed following a panic attack to gain their insight into the devices operation, and make optimisations where necessary. Ultimately it is the user that will determine the success (or otherwise) of the device.

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