A Context-Sensitive Device to Help People with Autism Cope with Anxiety

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Abstract
We describe a smartphone application that helps people with Autism Spectrum Disorder (ASD) cope with anxiety attacks. Our prototype provides a one-touch interface for indicating a panic level. The device's response—to instruct, soothe, and/or contact carers—is sensitive to the user's context, consisting of time, location, ambient noise, and nearby friends. Formative evaluation unearths a critical challenge to building assistive technologies for ASD sufferers: can regimented interfaces foster flexible behaviour? Our observations suggest that a delicate balance of design goals is required for a viable assistive technology.

ACM Classification Keywords
H5.2. User Interfaces: User-Centered Design.

General Terms
Design, Experimentation, Human Factors

Introduction
Autism Spectrum Disorders (ASDs) are a set of neuro-developmental disorders that cause deficits in social interaction, communication and imagination. As a spectrum disorder, the severity of ASD varies based on cognitive functioning and the perceived levels of deficit affecting an individual.

While ASDs cannot be cured, they can be managed by interventions designed to help individuals overcome the deficits. Intervention practices often occur in a therapy setting, and use an educational and behaviourist approach. They focus on teaching the individual how to deal with unwanted behaviour in an acceptable manner. The intensity and frequency of these sessions varies, based on a number of factors including severity of the disorder, type of intervention and availability of resources—crucially, qualified therapists.

Sadly, access to interventions may be limited. The increased awareness and diagnostic rate of ASD has led to a lack of skilled therapists available for the more intensive intervention practices. Also, little support is available outside the therapy setting, meaning that parents and carers have to attend to the individual with ASD at all other times. This has a significant social and economic cost—the US National Standards Report in 2009 estimated the societal cost for the lifespan of an ASD individual to be US $3.2 million [1]; the societal cost in terms of parental anxiety, stress, and depression is huge [2]. Interventions, therefore, need to be augmented by supporting practices.

Computer-assisted intervention has been effective in teaching language, reducing inappropriate verbalization, increasing functional communication, and improving generalization to a child's daily environment [3,4]. Assistive Technologies can be seen as a method by which issues specific to the ASD individual can be addressed outside of the intervention setting. They can provide support in situations where support may not normally be available. An example of *in situ* technology for autistic adolescents is Madsen et al.'s handheld device for facial expression recognition [5].

An assistive technology may require specialised hardware, depending on the function it is supposed to perform. Alternatively, software applications can be used to adapt off-the-shelf hardware, such as smartphones, into an assistive device. This allows the device to be more accessible, reduces the costs of development and deployment, and reduces the stigma associated with using an obvious assistive device.

We present an application designed to aid an adolescent with High-Functioning Autism (HFA) or Asperger's Syndrome with anxiety, a key issue faced by individuals with ASD. We focus on the design process of the application, taking into account the needs of the individual with ASD, their parents, carers and therapists, by consultation with all involved. We then iterate through prototypes of the application in response to the feedback received from users at various stages through the development lifecycle. The application is deployed on a smartphone, and has been implemented using Google's *Android* framework.

Concept and Design

The anxiety application is part of a larger, ongoing project that aims to develop assistive and early intervention technologies for people with ASD. Our design methodology for the application is decidedly pragmatic: it is intended to yield tools for our target group that are useful and attractive.

The genesis of the anxiety application was conversations between one of the authors and a friend diagnosed with Asperger's. This friend had dropped out of university due to an inability to cope with anxiety triggered by stimuli in that environment. We conceived of a device that would allow the user to mark the onset

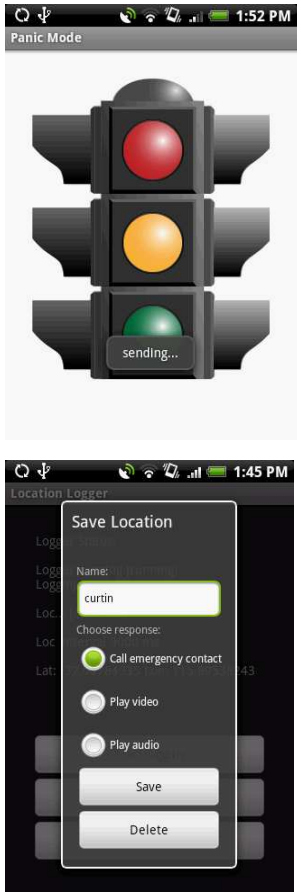

Figure 1. Above—active support screen, with button inputs for indicating panic, warning, and okay; Below—configuration screen for location-sensitive panic response.

of an anxiety attack, automatically sense the context at the time of the attack, and enable some level of intervention—either by delivery of video stimulus (e.g., social stories, which are used to teach social skills through concrete, idiosyncratic video narratives [6]), or by contacting a carer or friend. The use of context to modulate the device's response is motivated by the location- or time-correlated nature of many anxiety triggers. Default behaviour would cover response for attacks without a recognized or available context.

Consider a scenario by way of demonstration: John has just begun university, and must travel to the campus by train. He waits at the station, with the anxiety application running on the smartphone in his pocket. The train arrives, accompanied by a cacophony of screeching wheels, clanging level-crossing bells, and ensuing rush to board. John is transfixed by panic. He presses the panic button on the smartphone. It calls his mum, and she endeavours to talk him through the experience. It also records the time, place, and noise level. The train moves on, leaving him alone at the station. John knows the noise triggered an anxiety attack, but the cause of an attack is not always clear. The next day, John returns to the station with his mum. She uses the anxiety application to video John waiting as a train arrives amidst the noise, with her support, and he boards it. The following day he waits at the station alone. The train comes, he feels his chest tighten, he presses the panic button. The application, aware of the location, plays the video his mother recorded at the same place. He sees what he needs to do; that he has done it before. He waits the noise out, and boards the train.

The above ideal scenario glosses over an aspect of ASD that can potentially torpedo attempts at computer-based assistance: ASD's manifestations are highly idiosyncratic. The ASD population varies in what triggers an attack and how it is coped with, in addition to variation in cognitive function and preferences about visual and aural modes of interfacing with a device.

The device's primary goal is to help the user cope with an attack. We hope, too, that over time the device can support a measure of self-reflection, leading to better coping strategies; which we know, from talking with the mothers of affected children, can be a long process of maturing and learning to interpret one's feelings.

The platform to deliver assistance, a mobile phone, was chosen because it is typically always carried by its user, and does not have the stigma of a "special" device. In addition, smartphones are able to sense, be interacted with, and are a means of communication.

Consultation

Our design method is participatory as far as practicable. We have a partnership with a not-for-profit organization that provides services to people affected by Autism. Following initial discussion with a therapist and parent, we built the first prototype. Its function matched that of the device in our example scenario. This was then demonstrated at the premises of our partner to a small group consisting of a teenage boy with HFA diagnosis, his mother (youth group organizer and teacher), and a volunteer worker with a degree in psychology. The demonstration included hands-on play, and discussion of concerns or opportunities as they arose. The chief observations or requests to influence the design of the second prototype were:

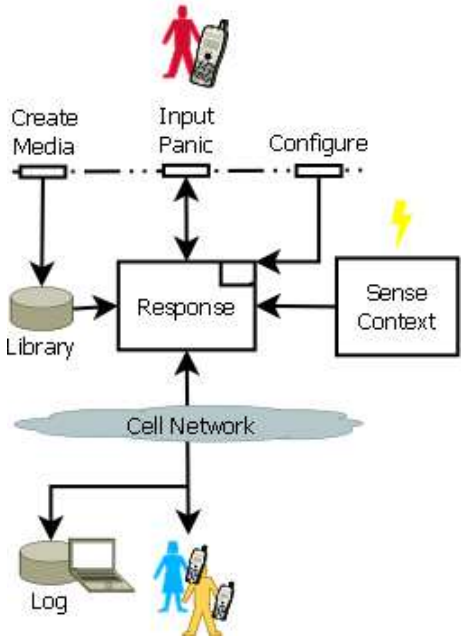

Figure 2. System architecture of the evaluated prototype.

- More options for how the device responds: I.e., different kinds of media, in addition to video—sound and music, recorded by the user or obtained from a library. The potential role for media to *soothe* rather than instruct was noted. The device should have a list of emergency contacts to try when the first is not available; and while attempting to contact that person, should be able to background the call, so as not to distress the user, and possibly play media while the user waits.

- Degrees of "panic level": The panic button was not deemed to offer sufficient grades of response—three levels of input were proposed: *panic*, *warning*, and *okay*. The middle grade, warning, was interpreted as alerting the parent while signaling that the child would attempt to cope without their help. It offers a stepping stone to independence, and fits with the final observation.

- The potential for the device to help **parents**: by alerting a parent to a panic attack, putting them in contact, logging their child's context, and providing reports, it would become a tool for parent and child to mutually help each other grow—the one toward greater mobility or independence, the other to adjust to that greater freedom. This is a real concern for many parents, and a device like this might help in what can be a difficult time of transition.

In addition, numerous minor modifications were made as a result of this consultation. We will now sketch the resulting system architecture and interface.

Prototype

Active support mode

In active mode, the screen displays three buttons corresponding to the two panic levels and okay. The application will predominantly be at this screen, for quick access in case of an anxiety attack. The three buttons can be customized to a degree, from among the traffic lights, shown in Figure 1, coloured rectangles, with or without text labels, and Compics, which are pictographs for simple concepts such as emotions. Tapping a button causes a log of the action to be created, and triggers the (possibly context-sensitive) configured response.

Response configuration

The user, or a parent, is able to configure the device's default response to the three buttons, as well as context-specific responses (see Figure 2). The device can do one or both of: call an emergency contact, or list of contacts; and play media. Media may be selected from a library, or created using a simple interface. For both panic levels and the okay, an SMS is sent to the primary carer with a context payload, including panic-level, location if available, and optional text message.

Context Logging

The application senses and logs various measures of the device's context. GPS, ambient audio, nearby Bluetooth devices, and panic level. This data serves two purposes: it enables context-sensitive responses panic modes, and is the payload communicated to the primary parent or carer.

Formative Evaluation and Discussion

The prototype resulting from the most recent design, described above, was evaluated during an interactive

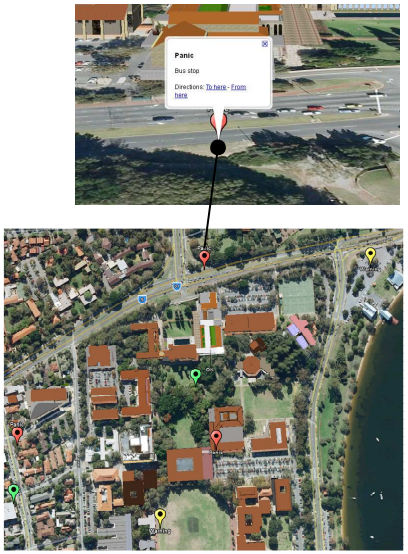

Figure 3. Mock-up report showing panic inputs by location. Context payloads, including panic type, sound bite, nearby devices, and text message, would be accessed from the same interface.

session with 4 teens with ASD, 3 parents, and 2 psychology students, and staff of our partner. The teens were introduced to the idea of our visit a week beforehand, and were reminded repeatedly in the lead up in order to prepare them for the change to their routine. We used a formal questionnaire to gauge their opinion about the current prototype and our proposed extensions, while eliciting new requirements.

We explained the purpose of the application, showed how to use it (with the aid of storyboards of task interactions), allowed time for hands on play and informal feedback, and then gave the questionnaire. Questions were kept to a minimum, as concentration was at a premium, in addition to typical questionnaire fatigue. Each question, in addition to enumerated responses, included space for an open-ended response.

The overall response to the application, scored on 5 point Likert scales for the typical facets— Usefulness Understandability, and Ease of Use—was very positive, with only one Disagree (2) for Understandability, and one non-committal response (3) for Ease of Use. Our cohort size is small, due to the difficult nature of organizing such an evaluation, so our conclusions are tentative. We interpret the overall result as confirmation that the anxiety application is worth development and a subsequent longitudinal field trial.

Of more value was the discussion that formed. Below, we crystallize the issues raised and discuss each.

Non-flexible interface to encourage flexible behaviour?
Two parents raised a concern that is critical to the tenability of active, in situ assistive devices for the ASD population. In short, the concern was that the teen might "fixate" on the device, and become obsessed with it. This would encourage the kind of dependence on tightly-structured interactions that parents and therapists are trying to train children to outgrow. It was noted that "change is hard." In the discussion that followed, one mitigating factor was noted by the same parents: age and/or level of function may render use of such an assistive technology necessary to other goals—i.e., the lesser of two evils. It was also suggested that younger children would benefit from being introduced to an assistive technology.

An extreme solution to unwanted dependence would be to remove user-initiated interaction altogether. I.e., use a passive device. In parallel, we are investigating passive devices in the role of anomaly detectors. These devices sense location, ambient noise, compass heading, accelerometer, etc., and record and aggregate a profile of normal behaviours against which anomalous behaviour is detected. Anomalies are pushed to the parent for intervention if necessary. Alternatively, the risk of dependence might be reduced with a predictably fluid interface. Interfaces that change go against UI design principles, but UIs are generally not designed to make themselves obsolete, which is the case here.

A related concern was device failure, in the case of, say, a flat battery. Technology for handheld devices is continually improving, but again the advantages of using the device must be weighed against this risk.

Who are the users—the teens or their parents?
The second part of the questionnaire was directed at the parents. It sought to gauge whether a report facility was viewed as a useful feature, and, if so, what kinds of reporting were desired. An example of the various

mockups of the possibilities provided to participants is depicted in Figure 3. All 3 parents thought a report facility would be useful. The most popular kind of reports were for instances of panic level, location, and time, and trends of each. Parents were less interested in sound bites of the device's context—raw, obfuscated, or labeled—or in who was with their child. Parents expressed the wish for reports "...in a form the kids can understand"—which suggests a self-reflective and educational use for the reports, and would necessitate display formats suitable to the children.

Not all "anxieties" are equal

One parent commented that "[her son] couldn't distinguish between anxious, hungry, tired, and lonely; he was just *low*". So interpreting mood itself can be a problem. We speculate that the emergency contact function could serve just as well to connect the teen to their parent so they can help be helped to interpret what they are feeling, and hence learn to distinguish between those states. This broadened the scope of the application from anxiety to *low valence*.

Conclusion and Future Work

We have described the design of a smartphone application aimed at helping people with ASD cope with anxiety. At the onset of an attack, it renders assistance by instructive or soothing media appropriate to the sensed context, and simplifies the process of contacting carers. In the immediate future, we will aim to fit the device for deployment in a longitudinal trial, particularly aimed at answering the challenge raised by the formative evaluation: how to best balance the risk of dependence with the benefits of an increased sense of security. We are also keen to explore if the device might be of benefit to people with other disabilities.

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