WAND: Walk Around Navigational Device for Children with Autism Spectrum Disorders

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CHI 2010, April 10–15, 2010, Atlanta, Georgia, USA.
ACM 978-1-60558-930-5/10/04.

Abstract
Children with Autism Spectrum Disorders (ASD) face many challenges, particularly with their ability to safely explore their surroundings. This paper presents a device and application that allows caretakers of children with ASD to encourage independent walking by safely prompting their child's navigation of paths in their neighborhood with security provided by the device's tracking capacity. This device not only motivates the child to walk through the use of its games and camera functions, but also aims to build social skills by facilitating social interaction in neighborhoods.

Keywords
Walking, Fitness, Health, Autism, Asperger's Syndrome, Cognitive Disabilities, Navigation

ACM Classification Keywords
H.5.2 User Interfaces (D2.2, H.1.2, I.3.6) Subjects: Graphical User Interfaces (GUI), Input Devices and Strategies, Prototyping, User-Centered Design.

General Terms
Design, Human Factors, Performance

Introduction
Walking, in any amount and at any pace, expends energy. Walking is a natural activity and the only sustained dynamic aerobic exercise that is common to

everyone except for the seriously disabled or very frail. No special skills or equipment are required [1]. Walking is a simple way to live a healthy life, it can be done at any location, it works multiple parts of the body, and it is a naturally social activity [2].

For children with Autism Spectrum Disorders (ASD) such as Asperger's syndrome, Rett's syndrome, and Autism, walking is particularly important. It is an effective means of addressing many of the physical, cognitive, and social impairments of the disorder.

Due to fewer opportunities to engage in structured physical activity, unusual dietary patterns, and increased sedentary behaviors such as television viewing, children with ASD have an increased risk of being overweight. Rosser and Frey report less time spent in moderate activity in children with ASD compared to children without [3]. While the overall prevalence rate of obesity is 16% for typical children, 19% of children with ASD are overweight due to nature of their disability [4]. Dynamic aerobic exercise, as in walking, enhances a multitude of bodily processes that are inherent in skeletal muscle activity, including the metabolism of high-density lipoproteins and insulin/glucose dynamics [1]. When done regularly, walking can be an effective weight management strategy for sufferers of ASD.

figure 1: Prototyped WAND device with stylus and map of home area.

Walking is also one of the most effective treatments for the cognitive aspects of ASD [5]. The benefits of light exercise for individuals with ASD are well documented. Exercise can help increase coordination, visual tracking, and mental processing, improve attention span, increase fine motor skills, and decrease stereotypic (self-stimulatory) behaviors, hyperactivity, aggression, self-injury, and destructiveness [6,5]. Taken together, these address the broad range of cognitive symptoms associated with ASD, which the American Psychological Association identifies as lack of spontaneous play, repeated and restricted patterns of behavior, and decreased attention [7].

Social impairment is also a major component of ASD. This includes limitations in the ability to share attention with peers, engage in imaginative play with others, and develop effective relationships [8,9]. Walking can encourage successful social engagement in two ways. First, though a single etiology of ASD ignores the diversity of those who are classified as having the disorder [8], it is apparent that many of their relational difficulties are a result of their cognitive impairment. For example, difficulty in following the attention of peers, problems in engaging in cooperative play due to misunderstanding social cues, and increased likelihood of aggressive behaviors means that children with ASD are unlikely to develop meaningful relationships. Walking, by improving many of the cognitive deficits, can help foster appropriate engagement with peers. In addition, familiarity with their physical environment can enhance their understanding of this environment. Secondly, walking allows those with ASD to explore their social environment. Walking can help them integrate themselves through engagement in similar activities. Simply co-locating children with ASD with full-functioning children is not enough to promote social inclusion [10]. Walking, however, by bringing children in close proximity and demanding joint effort on the part of a child with ASD, can increase social interaction and social play [11]. Walking is a socially mediating situation and gives ASD children and their typical peers a common context in which to socially interact.

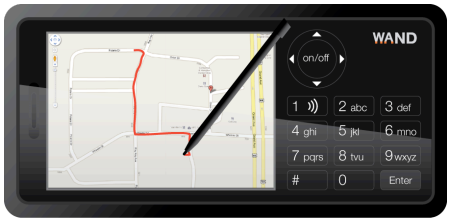

figure 2: Caretakers can choose the paths on maps of their neighborhood that are allowable for their child to walk along.

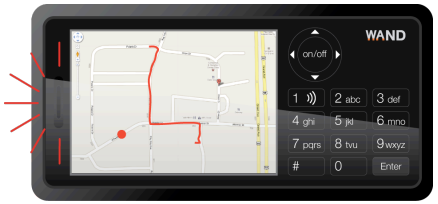

figure 3: Using GPRS the device can detect and alert the caretaker when their child is off their path.

It is unfortunate, then, that one of the most underutilized treatments for individuals with ASD is walking [5]. While walking is a common leisure activity for healthy children, it poses unique challenges for individuals with ASD. Typical children have no special challenges walking in their neighborhood. They know their neighborhood, they know where their caretakers allow them, and they can remember the way home. If a problem arises, they can communicate their needs. They are curious and walking allows them to explore their surroundings while meeting neighbors. Sufferers of ASD, however, have a difficult time processing multiple areas of sensory input simultaneously and can thus find walking in new areas to be overwhelming [12]. A limited ability to communicate verbally means that caretakers of those with ASD cannot allow them to walk without supervision.

Says the caretaker of an ASD child: "*I'm currently in tears right now. My 12 yr old son with Asperger's ran off yesterday […]. Just 1/2 hour ago, I got a call from child protective services because his school reported me (they have reported me 2 previous times, all unfounded) for not 'providing proper supervision.' […] I am so sick and tired of this. What can I do???*" [13].

As captured in this quote, the cognitive impairment of children with ASD does not severely limit their physical mobility. Children with ASD thus have a strong desire to imitate their peers and gain a sense of independence, but are limited by concerned caretakers and issues of safety. It is apparent, then, that there is need for a means of mediating the needs of exercise, social interaction, and autonomy for the sufferers of ASD while addressing their caretaker's concerns of safety and security.

Problem Identification

The need for an application that targets the most common disadvantage of ASD, social interaction, can be done in conjunction with walking. A city, and specifically neighborhoods, can educate individuals about the life that surrounds them and people in it; socialization can happen simply by taking a walk in the environment [14].

Toys or applications for children with ASD are usually done on an individual basis due to sensory preference, interests, and personality. Sensory processing difficulties are common with ASD children. Each child is unique and may have an aversion or deficit in different areas. By incorporating controls that allow the caretaker to modulate or to turn off or on sensory aspects such as sound, vibration, videos, and color, the device will be appropriate for a broader range of children and will not create sensory aversions [15].

Because of the dramatic increase in the number of people affected by ASD, it is appropriate and timely for our society to introduce a device that helps integrate and facilitate greater independence for persons with ASD into their communities.

Envisioned Solution

The proposed device and application, WAND: Walk Around Navigation Device, is an assistive technology that attempts to enhance or improve the independent living skills of children afflicted by ASD and their caretakers. With the larger goal of walking for fitness, the WAND device and programming teaches social skills with neighbors and friends by fostering independence through following routes during walking and the tasks of photographing and exploring their neighborhood. The

figure 4: WAND utilizes rewards through visual feedback, PECS, and/or games.

device can be taught inside the home environment and then introduced outside after mastery.

Utilizing GPS technology, GPRS connectivity, and alarm systems, the device is handheld with a touch screen and stylus acting as a wand. It is designed to be heavy duty, yet small enough to be portable, similar to the iPhone, with simplified controls and a long battery life. The package would include two portable devices, one child oriented, the other a home base for the caretaker. Both devices would be programmable by the caretaker. Children and adults with ASD such as Asperger's Syndrome generally have an affinity for technology, making assistive technology ideal for them, particularly in areas such as health and social interaction.

Caretakers can choose the paths on maps of their neighborhood that are acceptable for their child to walk. Due to the level of involvement these caretakers have with their children, it is reasonable and appropriate for initial customization by the caretaker. The WAND interface allows a child to see the path on screen and role-play the situation first and see boundaries on a map system before completing the walk. These maps and paths teach the proximity of the area and the distance that the child is allowed to walk from the home base. The method of visually rehearsing the route uses the video modeling technique of teaching that is commonly used for children with ASD.

Children can walk with their caretakers or independently. The distance of separation between the child and the home base can be determined by the caretaker and can be increased as the child increases in their ability to walk independently. Using GPRS, which has an unlimited range, data from the child's device can be transferred to the caretaker's device, and vice versa, cordlessly [16]. Vibrations and noise can occur when the child has strayed too far from the designated path to alert both the child and the caretakers.

When a caretaker is in the house and a child that is playing in the yard goes out of their allowed range, WAND can alert the caretaker and prompt the child. It also provides safety for typical children who walk alone. Caretakers will know when a child walks too far, which route they take, and where they are by the GPRS system. Therefore caretakers will be more comfortable having their children walk or play alone because it is not difficult to find them with the WAND device. This equates to previously impossible independence for children with ASD.

The inclusion of a camera on the device serves two purposes. The photographs serve as a visual diary, or breadcrumbs, of where the child has been. Storing those images provides reminders of what can be seen on that specific route. A picture is worth a thousand words and children with ASD who have difficulty with verbalization can use the camera as a tool for communication with those they meet or with their family. Also, the device can ask the children to take pictures of things along the way and compliance results in reinforcement by unlocking games to play.

Interest and motivation can be created through rewards on the device. Completion of walks, determined by the GPRS, or the taking of photos will unlock games the child can play. The games can be adjusted by the caretaker, turning on or off sound, color vibrancy, etc.

figure 5: The walk can be shown as a task list, without and with PECS.

figure 6: The walk can be shown as a map, with text or with PECS.

Due to some autistic children's limited ability to interpret symbols as representational of reality, the application can be likened to augmented reality rather than virtual reality; the imagery and maps can be tailored to be more realistic, akin to Google Earth images, or to be more simplified, with a layer of highlighting for allowed paths [17]. The design must be consistent, graphics based, not textually heavy, repetitive for memory enhancement, include no or limited time constraints, and provide demonstrations. Using the clearest language and pairing graphics with text will allow the users more comprehension, and keeping navigation consistent will benefit the users. Sensory-based accommodations can be made to address an individual child's processing needs and controlled levels can benefit arousal, alertness, and the attention level of the autistic child [12].

Screens of Application
Interfaces to be implemented in WAND:

- On and off options for sensory settings
- Choosing the location of child's neighborhood
- Map of neighborhood for setting walk limitations
- Map of neighborhood with walk options
- Photo capture and viewing
- Games

Icons of Application
Icons that would be implemented for selecting options:

- Home
- Camera
- Games
- Personal Folder

By incorporating flexibility in the presentation, with options of using maps with routes, PECS (picture exchange communication symbols), or instruction lists it allows the device to work for children of various skill sets and as they progress, the prompts can be faded to allow for versions with the least prompts, utilizing the ideation of discrete trial training.

Remaining physically fit is important for these individuals and WAND would remind them of the task at hand, track progress, and be a tracking device for caretakers in both traditional and emergency situations.

Future Work

While this product is targeted specifically at children and young adults with Autism Spectrum Disorders, its ability to trigger memory cues and provide a GPS of known routes could prove effective for persons with the cognitive disability of Alzheimer's. Alzheimer's is a progression of dementia from forgetfulness to total disability. The changes in lifestyle due to the illness represent a loss of independence and are a difficult transition for the individuals suffering from the disease [18]. WAND has the potentiality to prolong independence for those persons afflicted while giving peace of mind and tracking capabilities to caregivers.

Insufficient time for an IRB proposal and approval limited our ability to test a prototyped application with caretakers and children. However, research by monitoring blogs and support networks devoted to care of ASD reveals a real need for products which aim to do exactly what the WAND application proposes: motivate movement and social interaction while providing caregivers with means of security of the individual's whereabouts. The next step would be testing paper prototypes and doing revisions.

figure 7: The walk can be shown as a street view with path direction highlighted.

Conclusion

We followed a user-centered design process and created an application that has multiple functions for the intended users, beyond the immediate goal of walking; because of that, we are confident that the application will be successful as it covers a myriad of capabilities. This application represents the merging of walking for health, social inclusion, and independent living skill building in a technology that can be tailored to individual needs, for those suffering from an Autism Spectrum Disorder, with possibilities of use by typical children and individuals with Alzheimer's.

Acknowledgements

We would like to thank our faculty advisor Debra Satterfield and her son John Satterfield for their help and expertise on this project. We would also like to thank Roger Baer for his feedback during the project.

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