Broadening Accessibility Through Special Interests: A New Approach for Software Customization

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ABSTRACT
Individuals diagnosed with autism spectrum disorder (ASD) often fixate on narrow, restricted interests. These interests can be highly motivating, but they can also create attentional myopia, preventing individuals from pursuing a broad range of activities. Interestingly, researchers have found that preferred interests can be used to help individuals with ASD branch out and participate in educational, therapeutic, or social situations they might otherwise shun. When interventions are modified, such that an individual's interest is properly represented, task adherence and performance can increase. While this strategy has seen success in the research literature, it is difficult to implement on a large scale and therefore has not been widely adopted. This paper describes a software approach designed to solve this problem. The approach facilitates customization, allowing users to easily embed images of almost any special interest into computer-based interventions. Specifically, we describe an algorithm that will: (1) retrieve any image from the Google image database; (2) strip it of its background; and (3) embed it seamlessly into Flash-based computer programs. To evaluate our algorithm, we employed it in a naturalistic setting with eleven individuals (nine diagnosed with ASD and two diagnosed with other developmental disorders). We also tested its ability to retrieve and process examples of preferred interests previously reported in the ASD literature. The results indicate that our method was an easy and efficient way for users to customize our software programs. While we believe this model is uniquely suited for individuals with ASD, we also foresee this approach being useful for anyone that might like a quick and simple way to personalize software programs.

Categories and Subject Descriptors
H.3.3 [**Information Storage and Retrieval**]: Information Search and Retrieval - Selection process; K.4.2 [**Computers and Society**]: Social Issues - Assistive technologies for persons with disabilities

General Terms
Design, Human Factors

Keywords
Autism, preferred interests, software and technology design

1. INTRODUCTION
"If you've met one person with autism, you've met one person with autism." This quotation, often cited in the autism community, reflects a fundamental truth about autism: everyone diagnosed with the disorder is remarkably different. Since autism is, by definition, a spectrum-based disorder, it encompasses a broad range of phenotypes. As such, it is extremely difficult, if not impossible, to make generalizations about autism based on one encounter with one autistic person. This presents a problem for researchers developing new software and technologies for people with autism. How can we make computer-based interventions more accessible for this incredibly diverse population?

Our lab recently struggled with this exact question. We had just developed a computer-mediated intervention to help individuals with ASD manage extreme auditory sensitivity issues [1]. Our first participant, JH, was a 26-year old male who was extremely sensitive to the sound of people coughing. This became an especially challenging problem when a family member would get sick. The technology we created was inspired by exposure therapy research, and it was designed to gradually expose individuals to problem sounds (in this case, coughs) in a fun, engaging way until habituation ensued. To make the process engaging, we embedded the sounds within fun video games and other media activities; however, this was not sufficiently attractive for all of our participants. As we quickly discovered, it was very difficult to develop a single suite of games that appealed to all of our participants, some of whom had never even shown interest in using a computer.

Our participant, JH, had limited verbal abilities, cognitive impairments, and some motor difficulties. Prior to our study, he had never used a computer. His parents had often tried to get him to use a computer, but nothing they showed him attracted his interest. Knowing this, we decided to embed some of JH's preferred interests into our computer program. We hoped that his favorite images would engage his interest and encourage him to use the computer, and the games we had built.

At his family's suggestion, we first embedded family photos into our program, but these failed to attract JH. According to his mother, JH had always had a fascination with babies, both those encountered in real-life, and those depicted on television. Accordingly, we uploaded images of babies into the program and waited to see if they would attract JH's interest. All of this customization was done manually and yet JH was still not enthused.

His mother then suggested that we use a very specific category of baby photos – those taken right after or during birth – since she believed JH was most interested in "the drama of birth." We took her advice and uploaded realistic images of newborns taken right after birth. When JH saw this version of our program, he expressed excitement and delight and moved towards the computer. Soon, he was using the laptop by himself and was using the spacebar to control our program. The intervention also succeeded and he no longer has significant issues with coughing sounds. Further, we were also able to establish that JH's newfound interest in the computer was not simply a matter of getting used to the computer. After a few sessions, we switched back to the program that used family photos. But, this program did not interest him. He refused to use the computer and instead kept requesting "babies."

These results show that computer accessibility for individuals with autism may not just be a matter of designing intuitive programs that compensate for certain disabilities; the content may also need to be *highly* personalized. Moreover, personalizing for extreme special interests can be powerful enough to overcome an aversion – such as a painful or stressful sound. Because many people have strong, special interests that could motivate their learning to use a computer, we began to explore ways to make computer-based interventions easily customizable by anyone, not just a small coterie of computer programmers. We thus created a new Actionscript code library designed to help developers make highly customizable programs. When this library is utilized in Actionscript applications (such as Flash or Flex), end-users should be able to embed many kinds of image into their programs, and they'll be able to do so without having to alter any lines of code. In this paper, we describe this technology in detail, and we illustrate how it has special relevance for computer-mediated interventions for autism.

2. BACKGROUND

2.1 Autism Spectrum Disorde

Autism Spectrum Disorder (ASD) is a pervasive developmental disorder affecting as many as one in every 110 children in the United States [2]. It is characterized by cognitive, social, and affective impairments, and its symptoms range from mild to severe. Individuals diagnosed with autism often have sensory disturbances, and they can be especially sensitive to visual, auditory, and haptic stimulation [3],[4]. People with ASD may also suffer from sleeping disturbances, motor impairments, anxiety disorders, obsessive-compulsive disorders, gastro-intestinal symptoms, and a host of other comorbidities [5-9]. The precise pattern of impairments is unique for each individual, but generally speaking, individuals diagnosed with autism show the following three core diagnostic features: (a) communication impairments, (b) social difficulties, and (c) restricted interests and repetitive behaviors [10]. Restricted interests are an important diagnostic feature and they are particularly relevant for the technology presented in this paper.

In autism, restricted, repetitive behaviors are often grouped into two basic categories: lower and higher order interests [11]. Lower order interests are characterized by repetition of movement, and include motor stereotypies, self-injurious behaviors, object fixations, and repetitive manipulations of objects. Higher order interests, by contrast, involve more complicated behaviors, including repetitive language and obsessional devotion to certain, special interests (SIs). The type of SI can be highly variable across individuals and sometimes it can be developmentally appropriate and socially common, such as an interest in cartoon characters, movie stars, or computer games [12]. Other interests may be less developmentally common, such as extreme fascinations with washing machines, alarm clocks, or obscure historical events (see Table 2). Regardless of whether the interest is or is not common, it is often pursued with an uncommon fervor. Many individuals acquire extraordinary amounts of knowledge about their particular interest. This passion is rarely fleeting, and tends to grip the individual for extended periods of time [13].

When the interests are unusual, aren't shared by others around them, and when they consume inordinate amounts of time and attention, they can become a problem. Young children with strong SIs may fail to develop scholastic breadth. They may forgo academic assignments and instead give all their attention to material that directly relates to their SI [14]. While individuals can become experts at their SI, this knowledge doesn't necessarily generalize to other scholastic domains, causing developmental delays in learning [12]. In addition, if the SI is obscure or developmentally uncommon, it can be socially stigmatizing. Other peers, unfamiliar with autism or SIs, may cast aspersions on the individual and his/her SI, and may engage in inappropriate bullying behaviors. Some individuals may also find that they are unable or unwilling to talk about anything besides their SI [12]. As a result, conversations with peers may become one-sided monologues dominated by the SI. Individuals with autism are already at risk for social and academic difficulties. SIs no doubt magnify this risk and, as such, many researchers have explored ways to mitigate the intensity of SIs. Others have explored ways to redirect SIs into other interests that might be more adaptive.

For individuals with ASD, SIs are not always negative; in fact, for many, they can be the source of immense joy and solace [15]. SIs can provide structure and meaning that can't always be found in the blooming, buzzing confusion of the real world. For individuals with social difficulties, SIs can provide the comfort and pleasure that might not otherwise come from interpersonal relationships. Indeed, some individuals find great pleasure in the quiet company of their SI. Furthermore, in some occupations, SIs can be a tremendous asset that contributes to success. Attwood [12] reminds us that, when describing restricted interests over sixty years ago, Hans Asperger wrote, "It seems that for success in science or art, a dash of autism is essential [16]." That is, extreme focus and dedication to an interest can be a blessing, and can sometimes lead to strong careers in the arts and sciences.

SIs, when harnessed appropriately, and when embedded within educational curricula, can increase task adherence and performance. Most behavioral interventions that use SIs can be divided into two approaches: *consequent-based* and *antecedent-based* [11]. Consequent-based approaches leverage the SI as a reward that can be enjoyed after completing a task or after a period of good behavior. Antecedent-based approaches work by embedding the SI directly into the task at hand. For example, in an antecedent-based approach, a math workbook might present word problems that directly relate to the SI in order to engage the student. To our knowledge, no one has directly compared these approaches against each other in the context of an autism intervention, but research has shown good outcomes for embedding SIs according to either type of approach.

Research on consequent-based approaches has shown that, as a reward, SIs can be more effective than food at increasing task-related behaviors [17]. Also, research shows that if homework assignments involve some component of the SI (as in an antecedent-based approach), the rate of completion increases [18]. Other research suggests that SIs can be used to help build social skills. Several researchers used SIs in play situations to help individuals on the autism spectrum spend more time interacting with their peers [11],[19],[20]. In one case study [20], a child with an extreme fascination of maps was asked to play a game of tag with his peers. To encourage this play activity, the researchers set the game of tag on top of a giant outline of a US map. This simple modification put the child at ease and helped him play freely with his peers around the map.

Gagnon [21] expanded upon these approaches and developed an approach called "Power Cards" for use in autism. This method uses customized trading cards to help individuals with autism learn about social situations and routines. The concept is similar to work done with "social stories" (see [22]), except that, with Power Cards, each social story is customized to represent the preferred interest of the student. In her work, Gagnon found that the customized cards attracted the child's interest and provided a strong foundation for productive learning experiences. She observed that the power cards persuaded many students to engage in learning activities that they might have otherwise shunned or avoided. Follow-up studies using the Power Card approach have been used to help individuals on the autism spectrum work on a broad range of skills, including sportsmanship skills and conversational skills [23],[24].

Unfortunately, embedding SIs into interventions can be challenging and it is usually not a viable approach for most purposes. Caregivers and teachers often do not have the time, the materials, or the technical know-how to modify pre-existing interventions. In most cases, if you want to customize software for embedding SIs, then you have to be a programmer with access to the source code. Our work changes this situation.

2.2 Computer-Mediated Interventions

Many researchers have cited reasons why individuals diagnosed with autism might be well suited for computer-based interventions [25-27]. For one, software is predictable and algorithmic, and it therefore appeals to the many individuals who find comfort in stability and routine. Most software is also largely devoid of social complexity, eliminating a source of confusion that can come from human-administered interventions. Also, software has limitless patience and can provide the constant, indefatigable repetition that is often needed to teach difficult skills. Peer-reviewed research supports these notions and suggests that computer-based training may be useful for individuals with autism. There is evidence that computerized interventions for autism can help individuals gain skills in new areas, such as:

- speech production [28]
- social communication and problem solving [29],[30]
- literacy [26]
- emotion recognition [31]

New computer-based technologies for autism are proliferating quickly, and many have been developed as commercial products. Recently, Putnam and Chong [32] administered an online survey to see how new autism software and technology could be improved for household use. When asked an open-ended question about access concerns and design considerations, 19% of respondents specifically requested software that was meant to be fun to use. When asked about specific interests that might be targeted in new software, respondents suggested the following:

- movies, animations, and comic books
- science fiction genre
- artistic pursuits including writing, music and arts
- academic pursuits, such as reading and math
- animals
- transportation
- mechanical devices

Unfortunately, it is impossible for software and technology designers to fully anticipate the preferences of the end-user. General lists, like the one provided by Putnam and Chong, provide an excellent overview, but individuals with autism often have highly selective and idiosyncratic interests that defy general categorizations. In this paper, we present a solution to this design problem. We describe new computer technology that can help designers align software to a user's specific SIs.

3. IMAGE-PROCESSING AND RETRIEVAL ALGORITHM

Our software is written in Actionscript and PHP, and can be implemented in most any Flash program. At the core of our program is an image-processing algorithm, which can be loaded into any Actionscript program as an object. When implemented, our program first displays a search screen containing a blank text box into which the user types the SI.

The server identifies the URLs in the Google results, discards the ones that link to very large or small images or to images with strange dimensions, and passes the resulting list of image URLs back to our image-processing algorithm. The algorithm strips the images of their background, so they can be seamlessly integrated into any Flash program. The algorithm proceeds according to the following simple steps:

1. For each image downloaded to the server, the algorithm compares the colors of several edge pixels to determine whether the image has a solid, removable background. If it does not, it is discarded.
2. For the images it saves, the image-processing algorithm iterates through each edge pixel. It moves in a line perpendicular to the starting edge, continually setting pixels as transparent until it reaches a pixel that is different than the background color (Figure 1).
3. Step 3 is repeated, but the pixel destroyer moves in diagonal lines.
4. The image, which now should have a transparent background, is resized and displayed to the user on a tiled selection grid.
5. Finally, if the algorithm cannot find images that have removable backgrounds, it retrieves the ones initially discarded in step 1 and displays them on the selection grid.

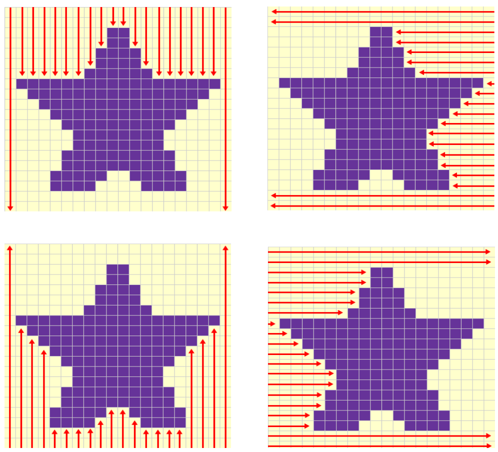

Figure 1: Background pixels are stripped away from the image. After moving perpendicularly from the top, left, bottom, and right sides of the image (as shown above), the algorithm proceeds in diagonal directions.

Images are displayed on a selection grid to the user as soon as they are processed, and the user may select an image as soon as it is displayed (Figure 2).

Once an image is selected, it can be passed anywhere within a Flash program. Depending on the program, the selected image could be passed in as a background image or, in the case of a video game, it could be passed in as a central character. Regardless of how the image is used, it is stored in local memory, so that the user doesn't have to go through this search process repeatedly.

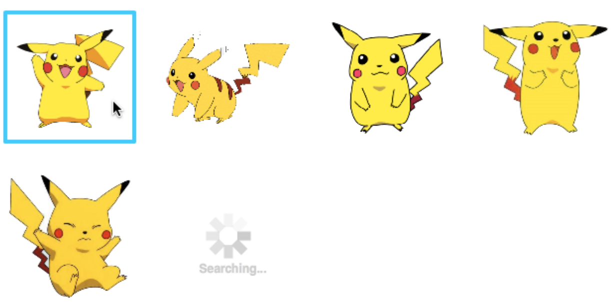

Figure 2: Processed images are presented on a grid. Users can choose any as soon as they appear on the screen.

The reason this process requires interaction with our server is that neither the Google Image Search server nor many of the servers that actually host the images contain a crossdomain.xml file. In order for Flash Player to handle data across multiple domains, it requires permission from the remote server in the form of a crossdomain policy file. Instead of requesting data from these domains directly, our software sends all data requests to our server (containing the necessary policy file), which downloads the data from the remote server and passes it back to our Actionscript image-processing algorithm. A simple PHP proxy handles requests sent to our server.

Our background-stripping approach works quite well, although it lacks scalpel-like precision. If the shape it is trying to 'cut out' is concave in certain areas, some scraps of the background color are not removed. There are several possible solutions. One is to continue tracing lines from the edge pixels using different angles. This would be effective in certain cases, but the marginal return for testing additional angles diminishes rapidly; after eight angles, additional line angles rarely have a significant effect. Also, there are certain shapes that will never be fully separated from their background, even if lines were tested at every angle. A recursive algorithm that identified all the background pixels by branching out from a starting point would be the most thorough and accurate way to remove the background, and would be similar to the "Magic Wand" tool in Photoshop. Implementing this effectively in Actionscript proved to be difficult. Flash can be slow and images need to be processed quickly, so the slower recursive algorithm wasn't practical. It is probably possible to write a recursive algorithm for this process that is efficient and effective, but for our purposes the iterative edge algorithm was sufficient. Another solution would be to have more of the image processing done by the server, although this might get expensive on a larger scale. We believe that most users will be happy to see their preferred interest represented in their software, even if the background of this image isn't always perfectly stripped clean.

4. SEARCH-RETRIEVAL STUDY

4.1 Procedure

To evaluate the efficiency and usefulness of our algorithm, we tested it on 50 different specialized interests. These interests were taken from ten publications and reflected actual interests of individuals diagnosed with ASD [11],[12],[19],[20],[23],[24],[33-36]. Some of the publications referred to lists of interests gathered from survey data, while others included lists of interests from individual case studies. As we expected, there was considerable variability in the interests we collected. Some reflected generic categories, such as "castles" or "planes", while others were highly specific (e.g., "electricity pylons" and "the letter 'A'"). Only three of the interests surfaced more than once (specifically "Thomas the Tank Engine, "planes," and "trains). This small degree of overlap shows why software should ultimately be customized by the end-user, not by the software designers. Since individuals with ASD tend to have such varying interests, and since many hold so intensely to their interest of choice, it makes most sense to give users the option to customize the programs according to their own preferences.

Of the interests we found in the literature, six were removed from our test because they could not easily be represented visually. For example, we decided that interests like "watching current movies" or "composing" couldn't be reduced to a single, representative image. Specifically, we removed these terms:

- Watching current movies
- Composing
- Rap music
- Swimming
- Role playing games
- Cartooning
- Sculpting

Also, when creating the search term for some of the more general interests, we occasionally chose a specific exemplar to help narrow down the results. For instance, for the interest "Disney characters," we refined the term so that our algorithm would search for a specific character, rather than that general class of characters. Overall, the *a priori* modifications that we made were not at all dissimilar from those that would be made by a real user. Ultimately, we believe that people would use our algorithm in the same way they might conduct a Google image search, and so we tailored our experiment accordingly.

For each search term we queried, we assessed the following:

- *Time:* How long (in milliseconds) did it take to retrieve the first appropriate image? An appropriate image was defined as an image that was suitable for embedding into software (i.e., it matched the search term exactly, it was resized properly, and it had most or all of the background removed).
- *Retrieval Position:* When was this image retrieved? Was it the first to appear, or did it appear only after other, less ideal images were retrieved
- *Google Position:* Where was this image located in Google's image search results (i.e., was it the first image Google retrieved? Or the tenth?)
- *% Area Resized:* By what percent was this image resized?
- *% Background Removed:* What percentage of this image was discarded as background?

4.2 Results

The experiment was conducted with an Ethernet connection that, according to speedtest.net, had a download speed of 32.85 Mb/s. The results of our study are summarized in Table 1 and they indicate that, on average, appropriate images were retrieved in about 2.5 seconds (M = 2435.22 msec). The images were not resized considerably (M = 16.59%), and about one half of each image was discarded as background material (M = 47.59).

Table 1. Results from the Search-Retrieval Study

Search-Retrieval Results	**Mean**	**Standard Deviation**
Time (msec)	2435.22	1800.68
Retrieval Position	1.24	.58
Google Position	3.83	4.76
% Area Resized	16.59	29.65
% Background Removed	47.59	22.05

While the test showed that our algorithm processed images quite quickly and efficiently, it did reveal one notable flaw – namely, for nine images, we had to add ".gif" to our search query before our algorithm could retrieve and process an appropriate image. A .gif is an image format that is often used for logos or simple art that uses few colors and has few well-defined edges. These properties make it ideal for our algorithm and so, at times, we had to include .gif in our search query. This bug can be fixed easily in future versions of the software. The program could be programmed to automatically include ".gif" in the query in case the algorithm fails to return an appropriate image.

5. USER STUDY

5.1 Participants

We conducted our user study with eleven students from the Groden Center in Providence, RI, a school that provides services to individuals diagnosed with ASD and other developmental

Table 2. Special interests used in the search-retrieval study

Powerpuff Girls	Pokemon	Anime
Thomas the Tank Engine	Weather	Kazuki Takahashi
Toy Construction Trucks	Ants	Machines
Barometers	Maps	Video Players
Graphing Calculators	The Lottery	Manga
United States Map	Castles	Vampires
Frogs	Goats	Disney Characters
Letter 'A'	Horses	Number Lines
Burglar Alarms	Airplanes	Windows
Vacuum Cleaners	Cars	Hurricanes
Washing Machines	Trains	Japanese Tea Parties
Clocks	Trucks	Britney Spears
Drain-pipes	Car Crashes	Plastic Beads
Dinosaurs	Thermometers	Greg McMichael
Drain covers	Fish	Electricity Pylons
Dolls	Star Wars	Kentucky Unforgettables
	Drumming	Dr. Who

disorders. Nine participants had an ASD diagnosis, while the other two were diagnosed with Prader Willi Syndrome/Severe Mental Retardation and Oppositional Defiant Disorder/ADHD/Mild Mental Retardation, respectively. To increase the variability in our ASD participant group, we asked the staff to include students with a wide range of abilities and functioning levels. Based on their estimates, they enrolled three students from each of the following general categories of ASD functioning: mild/moderate; moderate/severe; and severe/profound. It is important to note that these classifications were not diagnostically rigorous but were merely intended to help ensure that our user study included a broad range of participants. Also, the staff members that made these classifications were all naïve to the goals of our experiment.

5.2 Procedure

Game-play sessions were held in a quiet room at the Groden Center. A familiar staff member accompanied each participant to the room to help him/her feel more comfortable. Once there, participants were seated in front of a computer and told that they were going to play several different video games. Two different games were created for the experimental sessions, and each game had two versions: a *customized* version that featured images of each child's preferred interest and a *non-customized* version that contained generic content (Figure 3). Since some of our participants had verbal difficulties, we asked staff members to identify the preferred interests for each participant prior to the date of the study. At the time of the experiment, each participant's preferred interest was retrieved online and loaded into the game. The games used in the study were called "Find-It" and "Bounce" and, based on previous pilot sessions with other individuals diagnosed with autism, we determined both games to be comparably difficult. Both games tested control of the mouse, a task that is often very difficult for individuals with motor control issues. In "Find-It", players click on a target object hidden amongst a group of distracter objects. When the target is correctly selected, it changes from black-and-white to full-color. In "Bounce," players move the mouse left and right to get an object to land on successively higher cloud platforms. In both games, the preferred interest of the participant was represented directly in the game, and was a focal part of the game-play. Thus, these games reflected an antecedent-based approach to embedding preferred interests. A consequent-based approach, by contrast, would have used the preferred interest as a reward, only to be revealed when the player reaches a certain level in the game.

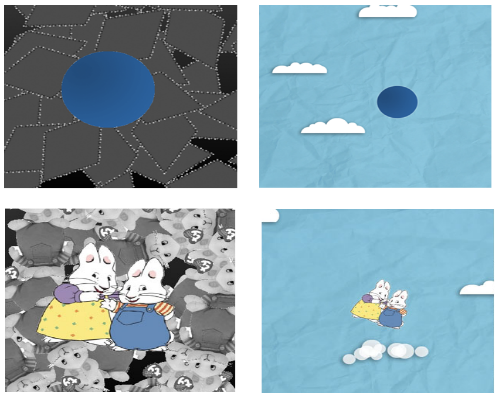

Figure 3. The four game conditions for one of our participants.

The order of the four game-play sessions was randomized for each participant, and each game was played for two minutes (figure 3). Afterwards, participants were shown tiled depictions of the four games they had just played. They were told they could play one of the games again, and that the game could be of their own choosing. Specifically, we said:

"Now you get to play one of the games again. Point to which game you want to play."

Since some of our participants had limited verbal abilities, we hoped that this selection method would be appropriate for everyone.

This user study was primarily designed to test our algorithm in the context of a real-world setting with individuals diagnosed with autism and other developmental disorders. We wanted to see whether the games could be customized immediately for each participant, and we wanted to see whether this customization appealed at all to the children. We also collected qualitative, observational data from the session to help inform future research in this area.

5.3 Results

Overall, the participants were very excited to see versions of their preferred interests represented in the games. While many of the interests were common (e.g., "Spongebob", "Max and Ruby"), a Groden staff member noted that none of the school's computer-based activities featured any of these characters directly. Hence, for most of the participants, this was likely the first time they had seen their preferred interest directly represented in a computer game at school (and possibly at home, though we could not confirm this).

Our algorithm correctly retrieved each participant's interest from Google and embedded the result directly into the games. Except for one interest ("Judge Judy"), the algorithm successfully removed the entire background from each image. The "Judge Judy" image was set against a gradient, and so only some of the background was successfully removed. In the free-play session, nine of the eleven participants opted to play a customized game. Three students decided to play a customized version of "Find-It", while six chose to play a customized version of "Bounce." The two participants that did not choose a customized game had autism diagnoses and were described as being at the mild/moderate and moderate/severe functioning levels.

One of the participants may have chosen the generic game simply because she was dissatisfied with the interest we embedded for her. Although the staff had suggested that we embed images from "Teenage Mutant Ninja Turtles" for her, on the day of the experiment she kept requesting another character instead. After her free-play session, we decided to customize the game once again, but this time according to the request she made during the experiment. Once the game was updated to represent this particular interest, she played the game contentedly and no longer appeared as distracted. This result showcases the value of highly flexible and efficient tools to provide customization. Content should be customizable at a moment's notice, since preferred interests may change from day to day.

One other participant chose to play a non-customized game. While he seemed happy to see his interest (the cartoon "Max and Ruby") represented in the customized games, he still chose to play a non-customized game during the free-play session. There could be many reasons for this result and, unfortunately, our experiment was not designed to tease out the various possibilities. One possibility, for example, is that this individual has a non-visual interest in "Max and Ruby." Throughout the experiment, this participant kept singing snippets of the "Max and Ruby" theme song. It is possible that the audio aspects of this show intrigue him more than any visual representation ever could. On the other hand, it is also possible to argue the opposite case; that is, the images of "Max and Ruby" may have been *too* engaging for this participant. If they were indeed too stimulating, they might have made the game even more difficult. For cases such as these, then a consequent-based approach would have been more practical. At any rate, we were unable to determine why this particular participant might have preferred to play a non-customized game during his free-play session.

Unfortunately, it was beyond the scope of this experiment to assess whether our customized games conveyed a distinct learning advantage. Nonetheless, even within our short session, we observed some evidence of how an embedded interest can enhance attention and motivation. One of the ASD participants had experience with computers but, according to the staff, his interactions with the machine were always limited to aimless mouse clicks and arbitrary keypresses; prior to our study, he had apparently never shown any goal-directed or functional behaviors on the computer. Yet, when he saw his preferred interest (Tacos) represented in the "Find-It" game, he grew very attentive successfully clicked on the hidden images, much to the amazement of the staff that accompanied him. It may be that this particular style of game was uniquely suited for this individual, and that the customization had little influence in his performance. But, the fact that he didn't show this behavior during the non-customized session of this game supports our hypothesis that the embedded interest may have been genuinely helpful for him.

6. CONCLUSIONS AND FUTURE WORK

Our software algorithm held up well to experimental scrutiny, both in a naturalistic user study and in a controlled search-retrieval study. The latter study addressed how well our algorithm could retrieve and process images related to 50 interests of individuals diagnosed with ASD. The algorithm performed extremely well, retrieving all the images efficiently and accurately. Still, future versions of this overall approach could be improved in a number of ways. First, the background-stripping process could be refined so that it works more effectively on a greater number of images. In addition, the software could be improved by allowing users to upload their own images, in case the user's preferred interest cannot be found in the Google image database.

The user study provided a naturalistic setting to test our software. Overall, the software performed robustly and was able to be easily adapted in the moment, providing quick and effective customization. Most importantly, the majority of our participants enjoyed playing customized versions of the games. They seemed delighted to see their preferred interests represented in the software, and this enthusiasm seemed to have increased their overall attentiveness and their willingness to participate in the experiment.

In the future, more research is needed to determine the best way to embed SIs into software programs. While our video games employed an antecedent-based approach, other applications might require a consequent-based approach. There are many ways to embed preferred interests into computer-based programs and, unfortunately, there is no obvious rubric to guide these design considerations. Ultimately, however, the real solution might lie in further customization. In addition to personalizing the embeddable content, new software programs could also personalize how that content is embedded. For instance, software designers could offer users a choice over when and how to incorporate preferred interests into a program. Different users and different software programs might call for different approaches, so it would be wise to build systems that offer several options. Flexible and easy software customization is, in our view, the best way to make computer-based interventions accessible to a wide range of users. And while this particular paper focused on users with diagnoses of ASD and developmental disorders, it should be noted that many individuals could benefit from this approach. Populations that don't usually gravitate towards computers, for whatever reason, could always benefit from new tools that make software more personalized and appealing.

Finally, any programmers attempting to build tools such as those described in this paper should pay careful attention to the terms of use specified by search engine being employed (e.g., Google, Yahoo! or the like). Developers should also make sure that their applications comply with the ever-evolving laws of fair use of copyrighted images.

Also, while our initial experiments were conducted with Google's image database, there is now a Yahoo! Search API which may offer significant technical improvements, including a built-in API for Flash-based programs. Furthermore, the Yahoo! API has lenient terms of use, and it prides itself as being "a truly open API with as few rules and limitations as possible" [37] thus making it an ideal resource for creating new search-based applications. We therefore encourage developers to consider Yahoo!'s search database as a resource. Updates to our instantiation of this project, including examples and source code, will be posted in the "projects" section of the MIT Affective Computing website: http://affect.media.mit.edu/projects.php.

7. ACKNOWLEDGMENTS

Our thanks Matthew Goodwin, Daniella Aube, Eliza Lane and the rest of the Groden Staff for helping us conduct our research. We would also like to thank the The Things That Think consortium and Bank of America for supporting this research. Any opinions findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of its sponsors.

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