

Introduction

Down syndrome (DS) is a disorder that manifests itself in disabilities that affect all three major types of capabilities (cognitive, motor, and perceptual). (Feng, Lazar, Kumin, & Ozok, 2010) describes these capabilities as channels. The fact that multiple channels are impacted by the disorder means societal accommodation via universal/inclusive design is markedly more difficult than accommodating individuals where only one channel is affected. Individuals with Down syndrome are classified as cognitively impaired, i.e. they suffer from intellectual or learning disabilities. Essentially they exhibit sub average intellectual functioning and limited adaptive functioning prior to the age of 18. The Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) has four levels of mental retardation delimited by intelligence scores (IQ). According to (Feng, Lazar, Kumin, & Ozok, 2010) the majority of Down syndrome sufferers experience what the DSM-IV considers a moderate to mild form of mental retardation; reflected by an IQ score in the 40-70 range. This means that with proper education and conditioning they could potentially live and work independently. Oftentimes Down syndrome patients are referred to as high functioning; i.e. despite the cognitive challenges inherent to their condition, they participate well as members of society. (Feng, Lazar, Kumin, & Ozok, 2010) notes however that despite various methods of intervention the intellectual capabilities DS individuals declines with age, a fact identified by lower IQ scores than neurotypical individuals at the same age. Even as the medical industry tries to reduce the occurrence of infants with Down syndrome, it is important to pursue inclusive strategies to actively prevent marginalisation of this group. This paper will look at how designers can design for the cognitive, social and motor challenges facing DS individuals and how these particular challenges define the design of a budgeting application for users with DS

Cognitive Characteristics

The word cognitive is defined by (Dictionary.com, 2009) as anything pertaining to the mental processes of perception, memory, judgment, and reasoning. Based on this definition we can say cognitive abilities are skills humans utilize to process mental information and function as we expect them to. Conversely (Urdang, 1983) describe cognitive impairments as conditions that inhibit knowing, thinking, learning, and judging skills.

In the book *Digital Outcasts* (Smith, 2013) informs us that ability and disability are characteristics that exist on a continuum. The evidence of this is revealed in the way Down syndrome affects individuals. In most cases, the cognitive abilities of the neurotypical individual can be predicted. On the other hand the range of challenges affecting Down syndrome patients varies in acuteness from person to person. According to (Lewis, 2005), when it comes to cognitive abilities, some DS individuals are wholly illiterate, exhibit vocabulary challenges, or face challenges with complex sentences. The challenges with complex sentences are evidenced by the fact that their reading abilities are typically two years behind their grade level a fact noted by (Feng, Lazar, Kumin, & Ozok, 2010) via (Buckley & Bird, 2001). Further research by (Feng, Lazar, Kumin, & Ozok, 2010) reveals that in the U.K. up to 35% of teens with D.S. could not read independently, something that is usually achieved by ages 8-9 in neurotypical individuals.

While illiteracy is an issue to be prevented by caregivers during the developmental stages of an individual, the prevalence of complex language is a societal characteristic that can be adjusted in various contexts. In fact the Convention on the Rights of Persons with Disabilities held by the (United Nations, 2008) lists "Plain language" as a communication requirement to increase access to public programs and services; many countries have in turn mandated laws to enforce this. Plain language is defined by (Cooper, 1989) as clear, succinct writing designed to ensure the reader understands as quickly and completely as possible. Utilizing plain language is an obvious step in order to facilitate universal or inclusive design which according to (United Nations, 2008) aims to provide products, environments, programmes and services to be usable by all people, to the greatest extent possible. See appendix for a Plain Language Checklist.

Social Characteristics

(Buckley, Bird, & Sacks, 2002) research reveals that most individuals with DS exhibit age appropriate social and emotional skills, in fact their social capabilities often outpace the development of their cognitive and motor skills. They have a strong command of social language and have neurotypical desires to communicate and socialize. According to (Kirijian, Myers, & Charland, 2001) individuals with DS are at risk of experiencing isolation as they transition from high school to adulthood. As their time within educational institutions and amongst peers diminish, the literary and communication skills obtained begin to atrophy. (Kirijian et al, 2001) set out to curtail this effect by working with the National Down Syndrome Society (NDSS) to create Web Fun Central (WFC) a web site for teaching DS individuals basic internet skills so that they could utilize the internet for communication and entertainment. The project was successful in its mandate and serves as a reference point designers targetting users with DS.

Physical and Motor Characteristics

The challenges facing DS individuals are not restricted to cognitive limitations. They face muscular issues (tone and strength) as well as issues with motor skills (both fine and gross). Muscle tone is defined by the (Medical Dictionary for the Health Professions and Nursing, 2012) as the degree of muscle tension or resistance during rest or in response to stretching. DS individuals suffer from loss of tone, also known as flaccidity. This affects their speech and is exhibited by what is best described as floppiness when their limbs are moved from rest. Low muscle tone also causes tiredness and muscle pain even after brief use. Weak muscles are also a pervasive physical challenge for DS individuals. (Mosby's Dental Dictionary, 2nd edition, 2008) define motor skills as the ability to make the purposeful movements that are necessary to complete or master a prescribed task. Motor skills are categorised as fine (precise coordinated movements) and gross (use of large muscle groups to coordinate body movement). Motor skill defects in DS individuals affect a host of activities including: writing, tracing, visual tracking, walking, running, jumping, throwing, and maintaining balance. Deficits in fine motor skills will likely affect the DS individual's ability to accurately interact with a touch or hardware based user interface (UI).

From (Sarason & Sarason, 2001) we find the identifying physical features of DS. These include a flat face, small nose, slanted eyes, and small square hands with short fingers. During computer and device use, small hands and short fingers may make the use of standard input hardware difficult.

Design Implications

A number of constraints have been observed by (Ma, Feng, Kumin, & Lazar, 2013) who investigated user behavior for authentication in Down Syndrome and Neurotypical users. In designing for DS users one must be mindful of constraints of the cognitively impaired individual. Some constraints include:

- Impairments with problem solving, attention, reading skills as well as, math, visual and linguistic comprehension.
- Low digit memory span (3-4 digits) while neurotypical individuals have a span of 7-8.
- Most DS individuals exhibit strong visual-spatial memory. While plain language can be utilized for labeling and instructions throughout the application, one can also take advantage of their predisposition to image based cues and instructions. This can be done by using consistent and repetitive symbols, and by avoiding abstract images in favor of literal ones. Voice-over can be used as well to reinforce what is on screen.
- Any interaction that requires a time dependent response must allow for a longer time to accommodate the cognitive impairments of the DS individual.
- One must also be careful not to rely heavily on case sensitive text, unless efforts will be made to visually notify the user of keyboard state.
- Tools requiring authentication must allow for a variety of methods that allow the DS user to authenticate based on cognitive and/or visual ease.

From (Kirijian et al, 2001)'s findings on Web Fun Central project we recognize that usability tests with DS individuals are more effective than employing individuals with similar cognitive impairments. While the cognitive issues may be the same, the variances in impairment in addition to the combinations of perceptual and motor impairments within a DS individual create unique situations during testing. The aforementioned variances means that it is somewhat difficult to prescribe a static UI for DS individuals. For WFC (Kirijian et al, 2001) employed a

preference testing module to determine the user preferences for building the UI. Preferences tested included: fonts, colors, photographs, illustrations, and animations. From this exercise we could opt to provide a guided tour/wizard in the budget application that allows the DS individual to choose interaction methods that cater to their specific usage patterns. While this model would be useful for the neurotypical user, inability to easily grasp an interface will prevent the DS user from using the application altogether. (Kirijian et al, 2001) notes that DS users were typically goal oriented and had become accustomed to finding links and buttons. Lack of guidance however meant that each interface became a “find the link” game, without consideration of context and purpose. In consideration of the budget application, open-ended usage may not prove effective for the DS user, instead guided interactions via wizards must be utilized. Since (Feng, Lazar, Kumin, & Ozok, 2010) have noted that DS individuals do well at understanding others voice-overs should be employed as a part of guided interactions to aid usage. At the end of the project, the WFC team compiled a list of design heuristics to be considered when designing for individuals with DS. These include:

- Provide clear guidance, feedback and rewards.
- Don't underestimate the impact of images.
- Remember that everything means something.

See appendix for Web Fun Central's complete list of Implications for designers as well as a list of General Lessons learned from the project.

Conclusion

Throughout this paper, findings painted the DS audience as a difficult but not impossible user set to design for. The basis of which is usually research, observation and testing with children. (Kumin, Lazar, & Feng, 2012) seek to counter such traditional findings with more recent research. Their findings reveal that childhood characteristics of DS individuals are in fact mutable and should not be used as a defining standard for all. Adult DS individuals as it turns out may achieve “high functioning” status through growth, training, development and experience that in turn likens some of their characteristics to their neurotypical peers. This however raises the fact that like neurotypical users, DS users vary in abilities and preferences, all of them are not high functioning. One may be inclined to ignore universal/inclusive design methods to target a segment of the DS user set.

One of the goals of this paper is to derive an approach for designing a budgeting application for users with DS. In determining a segment we can make a number of assumptions based on (Kumin, Lazar, & Feng, 2012) research on employment for adults with DS. (Kumin, Lazar, & Feng, 2012) believe that certain DS users can excel in computer-related roles such as: data entry and migration, inventory management, content and document management, competitive analysis, Scheduling/Datakeeping and Preparing billing statements. A cursory glance at this list reveals that cognitive functions said to be lacking in DS individuals will be required for successful performance. We can reasonably determine that individuals capable of these jobs are also capable of utilizing a budgeting application. In addition to aforementioned design patterns for this group, we can also determine a set of design heuristics by performing ethnographic research on DS users who fill these roles. The aim of this research would be to determine their training and education up to this point, as well as to find out if there are particular design patterns utilized in these various applications that the DS users show a predisposition for.

Appendix

Plain Language Checklist

A document, web site or other information is in plain language if...

The **Basic Approach** specifies and considers who will use it, why they will use it, and what tasks they will do with it. Consider if the basic approach:

- Identifies the audiences and is clearly created for them.
- Focuses on the major audiences and their top questions and tasks.
- Does not try to be everything to everyone.

The **Design** reinforces meaning and makes it easier for the audience to see, process, and use the information. Consider if the design:

- Organizes the information in a sequence that's logical for the audience.
- Uses layout to make information easy to find, understand, and use.
- Uses principles of good design – including appropriate typography, font size, line spacing, color, white space, and so on.
- Uses visuals to make concepts, information, and links easier to see and understand.
- For online information, minimizes the number of levels.
- For online information, layers information appropriately, avoiding too much on one page.

The **Structure** is well-marked so the audience can find the information it needs. Consider if the structure:

- Uses many informative headings to guide the audience to the key information most important to them.
- Helps the audience to quickly complete tasks.
- Breaks content into topics and subtopics that match the audience's needs for information.
- For a document, minimizes cross-references.

The **Hierarchy** helps the audience distinguish between critical and less important information. Consider if the hierarchy:

- Puts the most important information first.
- Omits unnecessary information.
- Uses visual design and language to distinguish between main points and supportive detail.
- Uses advance organizers for the whole and at the section, paragraph, and sentence level to give the audience a frame for subsequent information.

The **Language** minimizes jargon and uses sentence structure, strong verbs, word choice, and other similar techniques to ensure the audience can read, understand, and use the information. Consider if the language:

- Has a conversational style—rather than a stuffy, bureaucratic style.
- Is simple and direct without being too informal.
- Uses reasonably short sections, paragraphs, and sentences.
- Uses sentence structure, especially the verbs, to emphasize key information.
- Uses transitions to show the link between ideas, sections, paragraphs, or sentences.
- Puts titles, headings, and lists in parallel form.
- Uses words familiar to the audience.
- For online information, matches the text of links to the page title the link points to.

The **Author**—whether an individual or an organization—creates a sense of reliability and trustworthiness. Consider if the author:

- Demonstrates a concern for the audience.
- Anticipates the questions and needs of the audience.
- Uses an appropriate tone for the audience.
- Provides a revision date to show the age of the information.
- Shows how to get additional information.

The **Testing** conducted is appropriate for the combined impact, importance, and type and number of the audience. Consider if testing:

- Needed to be done.
- Was done.
- Was sufficiently and appropriately robust.

For the **Overall** assessment, consider if the audience overall can:

- Understand the main purpose and message.
- Complete the task.
- See how the design and the substantive content reinforce each other.
- Scan to find information.
- Follow the language easily.

Web Fun Central: General Lessons learned

The results of the usability testing offered interesting findings and provided A.K.A. with the foundation upon which it could develop the learning modules and games for Web Fun Central. It is these findings that will hopefully provide other designers with some interesting insights.

Fonts

- Contrary to the research A.K.A. had completed, A.K.A. found no preference for the Comics Sans Serif style font (handwritten). The repeated use of this font in materials designed for people with Down syndrome should perhaps be questioned.
- A.K.A. did find a preference for Italic Serif fonts, particularly at larger sizes in 'You Pick', 'Rate It', and 'Web Maker'.
- Font treatments with bright colors and outlines proved very popular. Treatments that added depth (extrusion) were popular.
- Large size words with a heavy bold treatment were popular (e.g. Futura Bold to emphasize a word).
- Accentuated words in a sentence, using color and scale worked. Most of the instructions in some of the modules were treated this way and no comments were made about reading difficulty.
- Stylized words treated with highlighted graphical elements (stars in the background, arrows, colored elements) scored very highly over plain text treatments.
- Font decoration made the text difficult to read (changed letter shape, obscured outlines, drop shadows).

Colors

- Color preference seemed relatively subjective, but some conclusions can be drawn from the patterns in the choices made. In general, darker colors were preferred, namely blues and purples (five out of six chose blue, purple or gray).

- Users were not limited to liking just combinations of primary colors in high contrast of hue comparisons. Many selections were tints and tones of one particular color or split complimentary colors, (e.g. more sophisticated color combinations were interesting to them. Orange with two blue tones was popular).
- Dull colors were not popular.

Graphics/Images

- A strong preference for images that were clearly identifiable (objects at a distance that were shown in their entirety). Context for the object did not seem relevant or important.
- Naturally colored images scored better than those that were colorized or digitally manipulated.
- Images of people were popular. Images of young attractive females/males scored very well. Generally male participants showed more interest in images of women and female participants showed more interest in males. Observers noted a number of comments such as: 'I like boys', 'He's sexy', etc.
- Action images with people jumping, dancing or gesturing scored well. Sports images scored high (e.g. girl playing soccer).
- Generally, photographic images scored better than illustrations. However, fun and whimsical illustrations were popular.
- Images that users had trouble identifying were unpopular (e.g. a machine sprocket, a close-up of a phone), especially when compared to images that they could easily identify.
- There was more interest in images of people who were of a similar age group or older. Pictures of young children were rarely chosen.
- Illustrations of stars were very popular (e.g. wallpaper for 'Web Builder', 'Rate It').

Animations

- Animations that combined bright colors with motion were preferred.
- When given the choice between animation of motion, size and color, most picked the animating colors.

- When an animation was personalized, the response was very favorable. The user's name written on a bouncing ball was chosen more often than a star on a bouncing ball. The computer screen with 'NDSS Design Team' rated exceptionally well.

Music and Sounds

- Cartoon sounds (fun, exaggerated) scored best.
- Pop music (BackStreet Boys) did very well. Classical and Country (fun, yee-haw type) were not widely popular. Sentimental music (Elton John) was second in popularity to pop, although this could have been the result of familiarity with the song.

Buttons

- Favored clicking the largest button on the page.
- Interested in clicking more on buttons with a dark background color and light text on top (high contrast).
- Buttons that make it clear what the user is to do scored very well. When it was clear the object was a button and/or the clickable area was shown, the button was more popular.
- Buttons with a clear clickable area (an outline shape) were popular. Framed buttons were preferred to floating buttons (e.g. underlines).
- Buttons with arrows pointing towards them were very popular.
- No clear findings on preference for button location (spatial preference).

Instructional Demonstrations

When shown a brief animation demonstrating how something works (e.g. a pull-down menu) participants often did not understand that they should wait until the demonstration was over before trying it. This was despite the text instructing them to wait.

Web Fun Central: Implications for designers

In addition to the specific design considerations generated by A.K.A.'s aforementioned usability testing, there are a number of more general implications that A.K.A. deems important to flag with designers communicating to individuals with Down syndrome and the general public. These include:

- Provide clear guidance, feedback and rewards. Clearly tell the user what they will find and how to find it. Open-ended, ambiguous content will not be effective without support. Positive reinforcement is very important from both a learning perspective as well as simple enjoyment.
- Don't underestimate the impact of images. Visual learning strategies clearly work best for this and other populations, but perhaps of equal importance is the treatment and quality of the design.
- Remember that everything means something. It is typical for individuals with Down syndrome to methodically scan every piece of information on the page in an attempt to garner meaning and direction. Designers cannot be careless with what they choose to design for them because every single variation, from image treatments to font changes, will be interpreted in some way by the user, whether any meaning was intended or not
- You have the means to teach skills, empower and support. The advances of rich interactive media offer a host of new possibilities for developing learning tools and games that specifically meet the needs of populations with special needs.
- Reach a whole new population of viewers. A.K.A. saw firsthand how mainstream sites frustrated individuals with Down syndrome. If these were treated in a slightly more user-friendly manner, without diminishing the overall design, they would have been considerably more accessible and the designers (and those who hire them) could reach whole new audiences.
- It can be done. Perhaps the single most important conclusion of this project is that in spite of the many unknowns and challenges in embarking on such an endeavor, if one

takes the time to value and understand design from the user's perspective, one can chart unknown territory and yield transformational results.

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