Cognitive Considerations In Interface Design For Children With Asperger's Syndrome: A Proposed Budgeting Tool

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ABSTRACT

The characteristics of a particular user need to be evaluated to inform the design in the field of Human-Computer Interaction (HCI) design (Demir et al., 2017). This research consists of an evaluation of the characteristics of Asperger Syndrome (AS) and a budgeting tool has been proposed for children with the AS. The research results show that simplicity, consistency, color-coding and efficient labeling in design helps to reduce the cognitive load of the children with AS, thus, make the design more usable and useful for them.

KEYWORDS: HCI, Asperger's Syndrome, Budgeting, Cognitive Considerations, User Experience.

Introduction

Education design challenges exist throughout the spectrum of ages and learning environments, from early childhood education to e-learning for adult learners. These challenges, coupled with differences in "learning styles", make it essential that practical User Experience design principles be employed in the development of educational products.

In examining the challenges surrounding educational design, it is imperative to understand the key factors that influence the design process. According to Etmer, Pariso, and Wardak (2013), the various factors "that influence the process as well as the final product" include:

> *(1) People, e.g., the client and/or audience for whom the design is being developed, the prior knowledge and previous experiences of the designer him/herself, and the knowledge and experience of production staff; (2) Contexts, e.g., environments in which the design is developed and implemented; and (3) Expected learning outcomes, e.g., impact of assessment and evaluation practices. (p.8).*

Many educational design challenges arise from the tension between these different factors. Thus, there is no "one size fits all" solution available to the educational design process. Therefore,

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the characteristics of the target audience in design play a crucial role in achieving the expected outcomes with a product (Demir, Kim, Current, & Jahnke, 2019)

This research focuses on cognitive considerations in interface design for children with Asperger Syndrome. The goal of this research is to examine research on the cognitive aspects of how Asperger Syndrome affects computer interaction, and apply this to the design of an online budgeting tool specific to children with Asperger Syndrome.

Autism, Asperger's syndrome, and cognition

Autism is a complex neurobiological disorder. Dr. Leo Kanner of Johns Hopkins Hospital in Baltimore first identified it in 1943 (Blacher & Christensen, 2011). Autism occurs in all racial, ethnic, and social groups and is four times more likely to strike boys than girls. Autism impairs a person's social ability to communicate and relate to others. Additionally, it is associated with rigid routines and repetitive behaviors. Today, 1 in 166 individuals is suffering from autism. The ratio of autism is more than pediatric cancer, diabetes and AIDS combined and may exceed 10 million of the population in the world (Hu, 2019). Dr. Hans Asperger described a form of the disorder that is still known as Asperger Syndrome (AS) or Asperger Syndrome Disorder (ASD) in 1944 (Freckelton & List, 2009). Asperger Syndrome is a neurobiological disorder characterized as a milder form of autism having varying degrees of impairment in communications skills, lack of social abilities and repetitive behaviors. The syndrome is not a common disorder and is without specific treatment or cure (Attwood, 2008) lasting throughout a person's lifetime. Asperger Syndrome is commonly recognized in children after 3 years of age and is more frequently diagnosed in boys. The cause of Asperger Syndrome is unknown, and there may be a genetic component of this syndrome.

To better understand the related cognitive effects of Asperger Syndrome, we need to review the meaning and the context of the term "cognition". Cognition is defined as "The process or processes by which an organism gains knowledge or becomes aware of events or objects in its environment and uses that knowledge for comprehension and problem-solving". Cognition is also a form of interpretation and making sense of the world such as understanding, reflection, and memory. Norman divides cognition into three levels (Norman, 2004);

- Visceral Level – the automatic, instinctive layer. Behaviors were related to immediate human responses to information.
- Behavioral Level – brain process that controls everyday behaviors such as language use, accessing both working and permanent memory, operations of learned behaviors.
- Reflective Level – contemplative part of the brain such as applications of the internal representation of experience, behaviors, and reasoning, problem-solving operations.

The Effects of Asperger's Syndrome

Individuals with Asperger's Syndrome have the intellectual capacity within the normal range; however, they can differ from normal ones in social and communication behaviors. User experience design-methods should be deployed to identify the characteristics of children with special needs (Spiel, Brulé, Frauenberger, Bailly, & Fitzpatrick, 2018). The main characteristics of the disorder shown in social interactions could be failure to establish friendships on the child's development level; problems on non-verbal behaviors such as eye gaze; impairment in the use of body language to manage social interaction; weakened ability to identify social cues; difficulties in conversation skills and problems in making literal interpretations; development of interests that

is unusual in intensity; the inclination to over focuses on details; difficulties in time management skills (Ersoy & Uysal, 2018; Vincent at al., 2019).

Cognitive Effects of Asperger's Syndrome

In terms of cognition, the main characteristics of the Asperger Syndrome are relevant to (I) Executive Functions, (II) Central Coherence, (III) Perspective-taking and (IV) Communication. However, the neurobiological effects of Asperger's syndrome are still poorly understood (McAlonan, Daly, & Kumari, 2002).

The cognitive difficulties in Asperger's syndrome may be repetitive thoughts, delay in language skills and weakness on response characteristics (Heasman & Gillespie, 2018). According to the research findings of AS, it is clear that people with AS can solve the various tests of the theory of mind tests, unlike those diagnosed with autism. A group of researchers conducted research to compare individuals with AS and autism and they found that individuals with AS performed significantly better than those with autism on the theory of mind tests (Barlett, 2005).

According to those research findings of AS, it is clear that people with AS can solve the various theory of mind tests, unlike those diagnosed with autism, however, they frequently display cognitive variances apart from findings in individuals' autism.

Individuals with AS perform relatively well on language and cognitive skills while also demonstrating normal level development with broader communicative functions. For example, very young children with Asperger's syndrome use their language for requesting, describing, gaining attention, and humor like their counterparts with normal development (Barlett, 2005).

Those with AS can have an intense and obsessive level of focus on things of interest. Similar to children without cognitive impairment, common interests can include transportation (i.e., trains), foreign languages, mathematics, computers, astronomy, geography, history, and dinosaurs. The primary difference in children with AS is the unusual fascination intensity of their interests that shows itself in a variety of ways including repeating words (Attwood, 1997).

According to research conducted on 37 AS adults who exhibit a normal level IQ, people with the syndrome can respond to problem-solving cues using their personal experiences but without those cues, they may not independently pull from their personal experiences or their accumulated knowledge database effectively. On the other hand, they have difficulty retrieving specific autobiographical memories. The research explains this phenomenon as encoding and organizing the specific events in their minds are not connected with those specific memories (Goddard, Dritchel, & Howlin, 2007). Some research also shows that adult AS patients don't use eyes to infer or read complex mental states or emotions in others (Baron-Cohen et al., 2006).

Learning Abilities of Children with Asperger's Syndrome

Some research indicates that the learning styles of children with AS differ from those classified as normal. The difficulty in learning is not directly related to brain functions or cognition of AS children and could be more related to engaging their interest within the structure of traditional education classrooms. Impacting their classroom experience, children with AS may encounter problems related to their social capabilities and as such, may need social instruction using a rule-based methodology because of their impairments in their social lives (Phemister, 2005).

Children with AS have intelligence close to the normal range and sometimes with higher averages than the normal group. This means they can not only learn but within a planned structure

towards their needs which encourages and motivates them, they can potentially learn better. Determining the learning structure (i.e, work than play) should be based on the personal interests of the children (Jordan, 2005).

Some of their particular classroom social problems may relate to impairment of non-verbal interpretation. As discussed in previous sections of the paper, understanding difficulties may occur from the lack of social understanding which is compounded by attention-related problems. Clinical research shows that attention may be impaired by distractibility and shows itself through the inability to cognitively shift focus as well as a lack of persistence (Kerr, 2002).

Individuals with AS can be poor incidental social learners to varying degrees. Students with AS may interrupt social situations such as making comments that are not relevant and difficulty initiating and terminating conversations. Abnormal staring or body postures may cause them to misunderstand gestures and facial expressions. Their thinking mechanism tends to be rigid and they have trouble applying similar lessons learned in one context into another and are not necessarily able to transfer lessons learned from a controlled educational environment to the real world. Another important point is that they do not learn from their mistakes (Kerr, 2002). Nevertheless, AS children can have good memories with high intelligence possessing the ability to learn and memorize what kind of actions are appropriate.

HCI for Children with Asperger's Syndrome

Individuals with Asperger's Syndrome are characterized by impaired social understanding and interaction. While significant cognitive impairment has not been measured in individuals with AS, the related cognitive disabilities of autism may impact their basic skills, social skills or both. Additionally, there may be other impacts such as an inability to manage time, distractibility, poor memory, and the need for extra time and extra support to complete tasks (Bodine, 2005). Microsoft researchers studied software that aims to provide online therapy for individuals with AS (Francis, Balbo, & Firth, 2009). They are presented with chat screens having pre-loaded social scenarios to practice their social interactions. As the child chats during the scenario, they are presented with facial representations of the simulated chat participants as cues to help them understand what types of facial expressions and eye gaze are typically associated with which type of social interactions. This is a good sample of a user interface for children with AS to treat their social impairments by using the appropriate tools in interface design.

For individuals with autism, they seem to lack an understanding of social rules and interactions making it common to repeat and stereotype experience rather than engage in new social activities. People with AS are engaging and have a well-developed vocabulary, however along with distractibility they have profound difficulties understanding abstract social concepts (Grynszpan, Martin, & Nadel, 2005). Therefore, it is important to keep their locus of attention on the task that leads them to completion in a reasonable amount of time.

Every additional effort to complete a task increases the 'Cognitive Overload' burdening the limited capacity of human information processing (Demir, Karakaya, & Tosun, 2012). HCI designs for individuals with cognitive impairments should primarily be concerned with reducing the memory load on orientation, navigation and user-interface adjustment (Thuring, Hannemann, & Haake, 1995). With their documented distractibility and short attention span, keeping the memory load as low as possible could help facilitate task completion while simultaneously limiting avenues of confusion.

A Budgeting Software for Children with Asperger's Syndrome

The characteristics of AS have been analyzed in the creation of the budgeting tool. The assumptions in the creation of the tool based on normalized society. The main goal of the budgeting software for children with AS is to create a product that is useful, effective and aesthetically pleasing. (Please see figures at the end for details).

The design consideration for the target users includes avoided reliance on emotional knowledge, used a combination of multiple communication methods, literal communications such as excluding idioms and slangs, maintained internal consistency such as regular and uniform design elements, clear obvious and consistent design throughout the application.

Methodology

This study serves to discover how individuals with AS interacting with a system that is designed upon the suggestions on the literature and design recommendations for individuals with AS. Literature that includes traits and factors regarding children with AS thriving and some computer application failing reviewed for commonalities.

Thus, a budgeting tool was created upon the findings in literature aiming the decreasing the cognitive load of the children with AS to let them complete the daily budgeting tasks easily. The goal of this research is to test the prototypes with the children with AS to see whether the users can achieve the tasks successfully and observe the interaction of the users with the prototypes.

A focus group interview is set to obtain user experiences and to test the proposed prototypes. A total of 6 children with AS participated in the study. The participants recruited through a regional health institution that is in charge of providing service for the AS. The study took place in a mid-western College campus in April 2017.

Through a higher institution located in mid-western in the US, an Institution Review Board (IRB) approval is obtained ensuring the highest scientific and ethical standards and protecting the participants' privacy before the data collection phase of the research.

Procedure

A regional health clinic invited the individuals diagnosed with AS with no significant delay in learning and cognitive abilities by distributing the study invitation via email. The study was designed voluntary-based participation and no incentive offered to the participants. A total of 6 parents responded to emails and expressed their interest in the study. A time that works for all participants set for the study and a complimentary parking pass emailed to each participant.

An interactive prototype on budgeting was created based on the suggestions in the literature. 6 participants invited to a meeting room furnished with 6 PCs with Windows 10 Operating System installed. The screen size of the LCD monitors was 19-inch and set to 1280 x 1024 resolution with Super-eXtended Graphics Array (SXGA).

They have informed that what if they are given $200 incentive how they are going to allocate the budget using the given tool. Each participant created a budget plan using the prototype individually without a time limit. A focus group interview is designed to retrieve their experience with the prototyping tool, expectations, challenges, needs and suggestions for further development.

Participants

The participants in this study were volunteers that have a diagnosis of Asperger's Syndrome that does not show a significant delay in either language or cognitive development. 6 children, 3 males, and 3 females participated in the study. The parental consents and child assents forms collected on-site as indicated in the IRB approval form prior to the study.

The participants' age ranges from 9 to 15. They all identified themselves as Caucasian and reported as able to read and write.

Results

This study serves to discover how individuals with AS interacting with a system that is designed based on the design recommendations for individuals with AS. The goal of the research was to know how the children with AS interact with the proposed budgeting tool and whether complete the pre-defined task successfully or not.

The participants were asked to complete tasks including registration to the system, entering the weekly income, creating a new budget, adding a new category, changing the amount of income and handling the error messages. All participants went through all tasks of creating a budget on how they would like to spend $200 incentive for a week.

The researcher does not interfere nor use any experimental manipulation during the task test as it remains the same for all participants. A semi-structured interview followed the task test to retrieve the thoughts about the design of the tool itself.

In order to analyze the interview data, a deductive approach was adopted because of a predetermined framework, design principles for children with AS in this case, retrieved through the literature review. The researcher used design recommendations from the literature to develop a tool to be tested.

The success rates in completing the task nor the time to complete the tasks were not monitored as the research designed the retrieve their perception. However, it is observed that all participants achieved to complete all tasks successfully.

The participants reported that simplicity in design helps them achieving the tasks easily. Well-known features in a design such as drop-down menus, one-click to access the next screen, a simulated calculator contributed to the ease-of-use with the products.

The consistency in the design such as deploying the same template repeated headers and footers, same color-coded pages gave them relief from stress and able to help consuming data presented on the screen.

The participants reported that they have had no issue understanding the content, information on the screen, error messages and button labeling. They indicated that green color-code for completed tasks and red-color-code for error messages meaningful to them when navigating the system.

Additionally, the low text on each screen and more visual elements such as icons and tables found intuitive and easy to consume information thus decreasing the cognitive load of the participants.

Two participants to calculate the total amount before they put the numbers into the prototype have used the pop-up calculator feature usable. However, they reported that the calculator image should be simulated the same as they used with their cellphones would be more intuitive.

Limitations

The small sample size is one of the concerns of this study. The more participant would give a better understanding of the topic. It is a fact that participants' characteristics can vary from person to person. The attitudes of the individuals participating in the study can greatly differ based on various life experiences that a person is undergoing at that particular time. A person's attitude has the potential to change multiple times throughout the day based on daily occurrences. If someone is interviewed during a time of unusual emotional distress, this could greatly skew results.

Moreover, individuals with AS may show significant social and emotional instincts, particularly at the time they have been invited to an interview as a group. Being in a social environment with strangers may have an impact on their attitudes during the study.

Conclusion

Those with AS do not show a significant delay in either language or cognitive development unlike individuals with autism. However, impairments related to autism may affect individuals with AS though there are currently no clinically known effects related to cognition. The characteristics of the kids with AS identified as lack of consistency and lack of preference for routine, unwieldiness and over insensitivity in motor responses. While HCI design for children with AS is similar to the design needs of normal children, the characteristics of the AS were taken care of in the design process.

Therefore, the critical design aspect for AS children are identified as keeping the applications and user interfaces as simple and with as few distractions as possible. Supporting the aspect of simplicity and limited distractions, some potentially helpful features identified as user-centered designs featuring leading prompts helping to keep the attentive focus on the task; minimally tasking the user's memory load; ease of navigation and item discovery; clearly defining the user's purpose and role; use cognitive models designed toward remembering and recall ease (i.e. short names and short items); deep colors for ease of identification and the same hues of the same labels; keeping visual continuity with a consistent and stable screen layout. As it is addressed in the literature (Francis et al., 2009), once the participants completed the tasks successfully, they presented facial expressions and expressed their happiness by clapping hands as a type of social interaction.

When teaching is connected with personal life experiences, it offers a greater learning opportunity for success no matter the user. They manipulated the designed application by the mouse-click interactions that they have already learned before the study. Moreover, personal budgeting tools could serve as a personal life experience for concept implementation managing their budget in their daily life.

Using that example and pairing it with the suggested helpful features to help teach AS children, budgeting tools and user interfaces should be simple and with as few distractions as possible to support the learning process. If presented with complex process flows and tasks, users can become confused and unsuccessful. To counter that, the amount of computer interaction and task process flows need to be at a minimum while the task is completed (Kerr, 2002).

Under certain conditions, the budgeting tool should orientate users automatically featuring prompts showing them the correct path with clear and relevant information in simple terms. When the user selects an object, (i.e. if they pressed 'select payment type') a list of objects or a list of possible actions can be performed on the screen to guide them to achieve a task more efficiently.

These types of simple cues help users to perform task options at any time, thus reducing confusion and the number of errors made. Especially kids with a habit of over-focusing on a theme in interaction require avoiding the placement of unnecessary items on the screen in order not to increase the cognitive load.

To sum up, the characteristics of the target audience always matters in user experience design. In this study, a proposed budgeting tool was designed upon the findings of the literature. The prototype was tested with the children with AS and validated that the simplicity in design leads them to achieve users' daily tasks in budget management.

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Figures

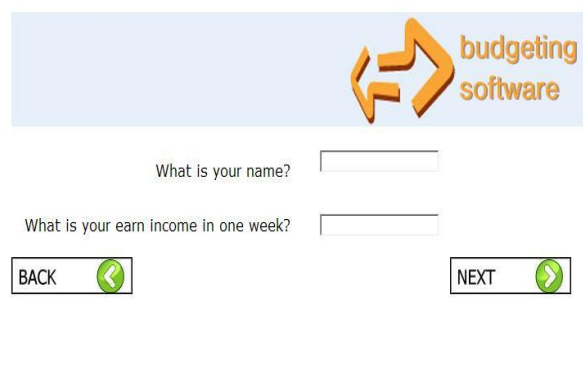*Figure 1*. Budgeting tool welcome screen.

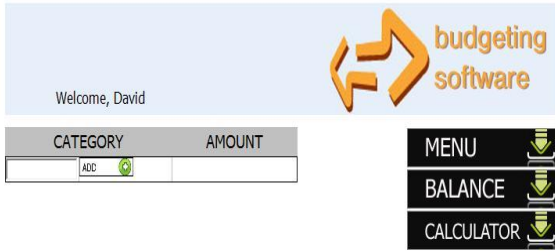*Figure 2*. Registration screen.

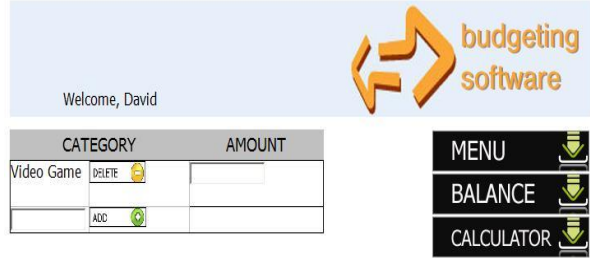*Figure 2*. Create a new budget.
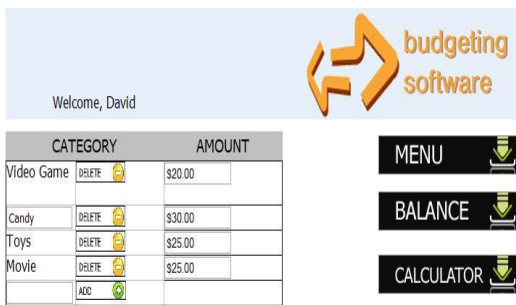

Figure 3. Add a new category.
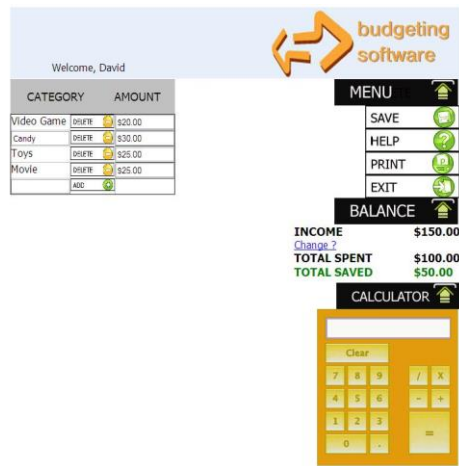

Figure 4. Sample entries.

Figure 6. All menus expanded.

Figure 7. Change income.

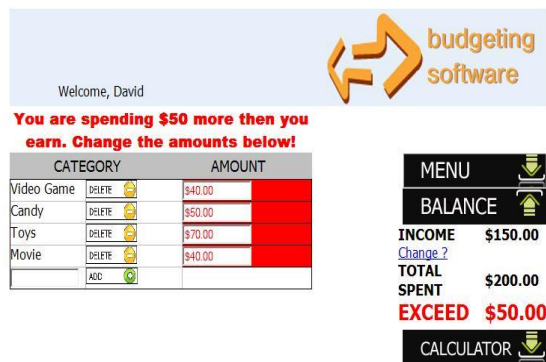*Figure 8*. Error message.